

DOCUMENT RESUME

ED 265 359

CE 043 316

TITLE Aircraft Pneudraulic Systems Mechanic (AFSC 42354).

INSTITUTION Air Univ., Gunter AFS, Ala. Extension Course Inst.

PUB DATE 16 Mar 84

NOTE 727p.

PUB TYPE Guides - Classroom Use - Materials (For Learner) (051)

EDRS PRICE MF04/PC30 Plus Postage.

DESCRIPTORS *Aviation Mechanics; Behavioral Objectives; Correspondence Study; Engines; Equipment Maintenance; Equipment Utilization; *Hydraulics; Instrumentation; Learning Activities; *Mechanics (Process); Military Personnel; Military Training; Postsecondary Education; *Power Technology; Recordkeeping; Records (Forms); *Technical Education

IDENTIFIERS Air Force; *Pneudraulics; *Pneumatics

ABSTRACT

This four-volume student text is designed for use by Air Force personnel enrolled in a self-study extension course for aircraft pneudraulic systems mechanics. Covered in the individual volumes are shop administration; fundamentals, materials, and equipment of pneudraulics; pneudraulic components; and pneudraulic systems. Each volume in the set contains a series of lessons, exercises at the end of each lesson, a bibliography, and answers to the exercises. Supplementary volume review exercises and change supplements are also provided. (MN)

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AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC (AFSC 42354)

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1. CHANGE FOR THE VOLUME REVIEW EXERCISE: VOLUME 1

The following questions are no longer scored and need not be answered:
81 and 82.

2. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 2

a. Page 2, question 1: Change "(003)" to "(200)." Question 2: Change "(004)" to "(201)." Question 3: Change "(005)" to "(201)." Question 4: Change "(006)" to "(202)." Question 5: Change "(007)" to "(202)." Question 6: Change "(008)" to "(203)."

b. Page 3, question 7: Change "(009)" to "(204)." Question 8: Change "(010)" to "(205)." Question 9: Change "(011)" to "(206)." Question 10: Change "(012)" to "(206)." Question 11: Change "(014)" to "(207)." Question 12: Change "(016)" to "(208)." Question 13: Change "(017)" to "(209)."

c. Page 4, question 14: Change "(018)" to "(210)." Question 15: Change "(019)" to "(211)." Question 16: Change "(020)" to "(212)." Question 17: Change "(022)" to "(212)." Question 18: Change "(033)" to "(213)."

d. Page 5, question 19: Change "(025)" to "(214)." Question 20: Change "(026)" to "(215)." Question 24: Change "(032)" to "(218)."

e. Page 8, question 39: Change "(29)" to "(229)."

f. The following questions are no longer scored and need not be answered:
53, 68, 69, 93, 116, 117 and 118.

3. CHANGE FOR THE VOLUME REVIEW EXERCISE: VOLUME 3

Page 14, question 81: In the stem of the question, change "figure 6-14" to "figure 6-12."

4. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 4

a. Page 3, question 9, choice b: Change "use" to "used."

b. Page 6, question 25: In the stem of the question, change "taxied" to "towed."

c. Page 11, question 63: In the stem of the question, change "sproket" to "sprocket."

NOTE: Change the currency date on all volumes to "May 1983."

42354 00 S02 8211

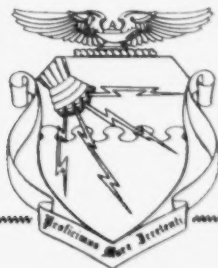
CHANGE SUPPLEMENT

CDC 42354

**AIRCRAFT PNEUDRAULIC SYSTEMS
MECHANIC**

(AFSC 42354)

IMPORTANT: Make the corrections indicated in this supplement before beginning study of Volumes 1 and 2. This supplement contains both "pen-and-ink" changes and replacement pages. It is perforated and three-hole-punched so that you can tear out the replacement pages and insert them in your volumes. You are not required to post any changes listed in this supplement which correct typographical errors, unless such errors change or otherwise affect the meaning of the material.



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CHANGES FOR THE TEXT: VOLUME 1

Pen-and-Ink Changes:

General: Throughout Volume 1 change all references to "AFM 50-23" to "AFR 50-23" and all references to "AFM 39-1" to "AFR 39-1."

<i>Page-Col</i>	<i>Subject</i>	<i>Line(s)</i>	<i>Correction</i>
62L		3	Change "Whan" to "When."
163R	034-1		Change "9H8-568-2" to "9H8-5-68-2."

CHANGES FOR THE TEXT: VOLUME 2

Pen-and-Ink Changes:

<i>Page-Col</i>	<i>Subject</i>	<i>Line(s)</i>	<i>Correction</i>
159L	201-2		Change "square" to "cubic."
159R	204-5		Change "100" to "400."
	205-2		Change "39.2" to "68°."

Page Changes:

<i>Remove Pages</i>	<i>Insert Pages</i>
91-96	91-96
163-164	163-164

Test Instruments and Nonpowered Aerospace Ground Equipment

THE PNEUDRAULIC systems mechanic performs maintenance that requires the use of electrical test meters, a leak tester, and nonpowered aerospace ground equipment. His duties will include such maintenance activities as troubleshooting systems, repairing hydraulic components, and servicing the pneudraulic systems.

All test equipment is used to measure some quantity of an operating device or systems. This can be pressure, volume, speed, size, etc. In this chapter we cover two pieces of test equipment you will find useful; the multimeter, which will measure the electrical quantities of voltage, current and resistance; and the ultrasonic leak detector, which will locate an internal or external leak by the sound it makes.

Jacks and maintenance stands are also used by the pneudraulic systems mechanic. Jacks are used mainly to raise the aircraft wheels off the ground for working on the landing gear and wheels, and for making retraction tests. Maintenance stands have hydraulic elevating gears to raise them. They are used for working on aircraft sections that cannot be reached from the ground. In this chapter we will cover maintenance stands, their construction, operation and use. In some cases you will be required to maintain this equipment. Even if you are not required to maintain it, you are liable for any damage incurred to its misuse or abuse.

Other nonpowered aerospace ground equipment you will often use are hydraulic and nitrogen servicing carts. In this section we shall cover the use and operation of an air/nitrogen servicing cart and hydraulic fluid servicing cart.

4-1. Testing Instruments

Without electrical troubles there would be a marked reduction in the work that the pneudraulic mechanic has to do. However, identifying and locating electrical troubles can be an exciting and thought-provoking part of your work. Most troubles that are apt to occur in any electrical circuit will stem from two basic causes; an open circuit and a short circuit. The meter you will use to detect these troubles will be the multimeter.

The pneudraulic systems mechanic must also locate leaks in a hydraulic system. If these leaks are in an open area they are quite easily seen. If however, these leaks are

in an area that is not accessible they become difficult to find. The tester that we will cover to help you locate the inaccessible leaks is the ultrasonic leak detector.

250. Specify precautions for use of the multimeter, and from given situations specify control knob setting and/or meter readings of a multimeter.

Multimeter Control Knob Setting and Meter Scales. The AN/PSM-37 multimeter, one of which is shown in figure 4-1, is a typical general purpose, precision test instrument. It is used for measuring volts, amperes, and ohms. The PSM-37 can be used to check alternating current (AC), direct current (DC), and AC and DC voltage which are read on the lower scale. Use the upper scale to read OHMS.

The range selector switch is used for selecting the desired scale range. The range switch is then set to the maximum values of voltage and current to be measured or the multiplier for the resistance checks. The maximum range setting are those numbers below the lines. The multipliers are the RX numbers above the line.

The function switch is in the lower left on the meter front. This switch is used to set up the meter to read volts, amperes, or ohms. You would use the MA PULSE MA position for current checks, the LP and STD for resistance checks and the 20K Ω /v, 1K Ω /v, or the 10M Ω for the voltage checks.

The OHMS ADJ is used to zero the pointer on the ohms scale. The pointer must be zeroed to compensate for a decrease in battery voltage due to age and use.

The polarity switch, located on the right side of the meter in figure 4-1, is used to turn the multimeter on and off. This switch also sets the meter to test DC +, DC -, or AC. The + and - signs mean the polarity that must be applied to the red test lead when you make DC measurements so that the meter pointer will move up the scale to the right. If the pointer moves to the left, just change the polarity switch to the other DC setting or reverse the test leads in the circuit. When you make ohms check, the + and - will mean the output polarity of the red lead. The shape of the polarity switch knob will not allow the cover for the meter to be put on unless the switch is placed in the OFF position.

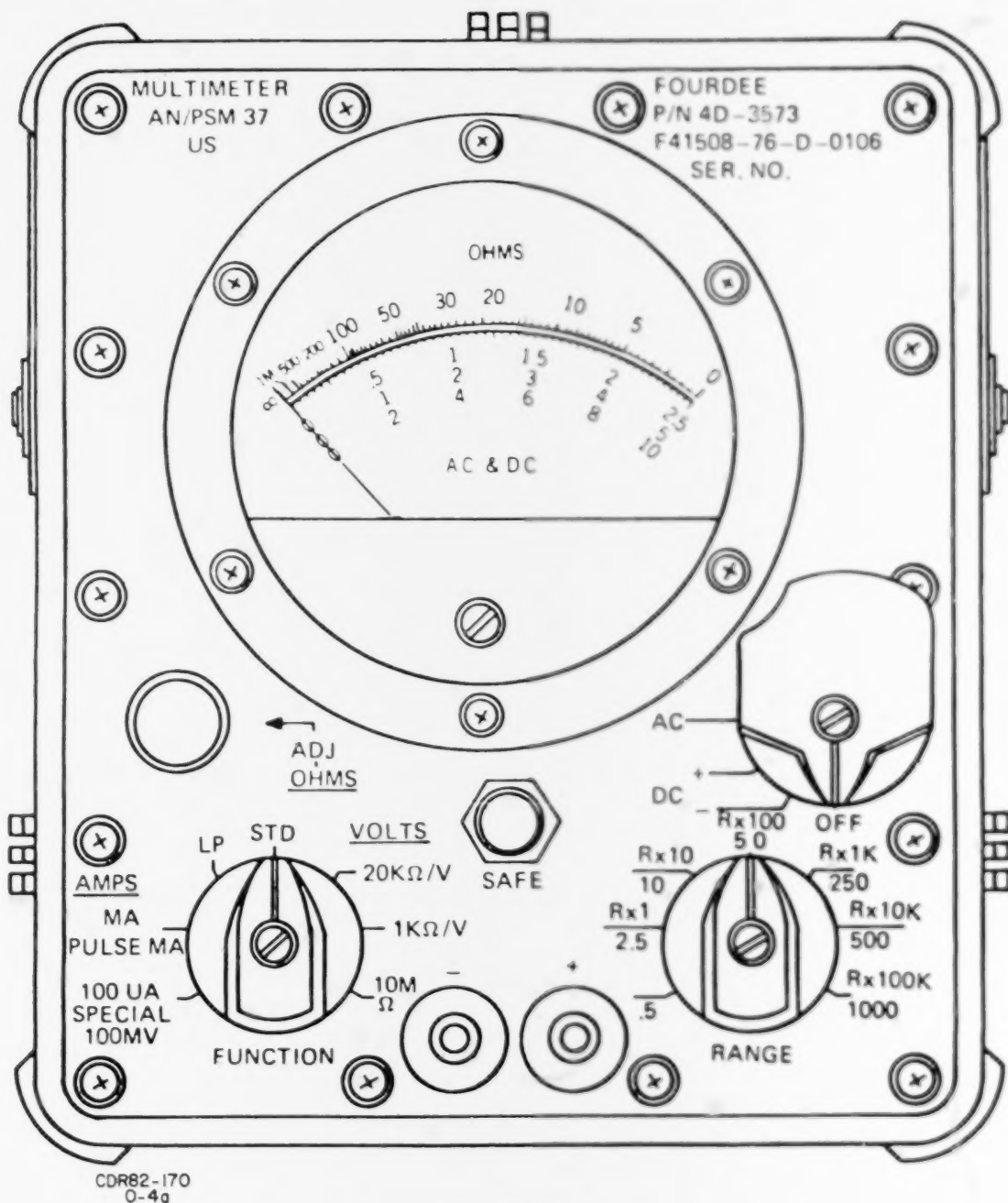


Figure 4-1. PSM-37 multimeter

The safe switch is a make-and-break type switch, which is normally closed. The switch is pressed to open the negative input of the multimeter while connecting the multimeter to a circuit for measurement. This method is used as a protection for the meter during the initial surge charge when first connecting the meter to a circuit with high power loads. Once the meter is connected to the circuit and the normal flow of current resumes, the safe switch is released. Then the safe switch acts as an overload

protector that automatically will open the circuit in case of an overload.

Setting Up a Multimeter for Voltage Checks. Electrically controlled hydraulic components may be powered by either AC or DC voltage. Let's assume that the components being checked operate on 28-volt DC. Using figure 4-1 in this case, set the FUNCTION switch to 1KΩ/v position. Next, set the RANGE switch to the desired range, which in this case would be the 50-volt

selection. Whenever taking an unknown voltage measurement, always set the range switch to the highest range and decrease until proper range is reached. Now turn the polarity switch to DC+ or DC-, whichever is desired. Next, install the test leads into the input jacks. Connect the test leads to the circuit being measured, with the black to ground or the lower voltage point, if known. If the meter reads in reverse, change the polarity switch to the opposite polarity. A voltmeter is always connected to the circuit in parallel across the conductor or the unit being measured.

After properly connecting the test leads, you are ready to take the voltage readings. The voltage reading is taken on the 0-5 division (center) of the AC & DC scale. This scale is used for the .5-, 50-, and 500-volt selections. For example, put the RANGE selector on the 50-volt setting. If the pointer points to the 3 on the 0-5 scale, the voltage indication is 30 volts. Likewise, on the 500-volt setting, if the pointer points to the 3, the voltage indication is 300 volts.

From previous discussions, you learned that a certain amount of voltage is expended in forcing current through a resistance. Any time there is a difference in voltage between two points, current flows. A voltmeter measures that difference in electrical pressure. If there is no difference between the voltmeter lead touchpoints, it will read zero.

Figure 4-2 shows a circuit containing several voltmeters with various voltage indications. To properly troubleshoot an electrical system, you must understand why the various voltage indications shown in figure 4-2 were obtained.

Notice that the voltmeter D indicates 24 volts, which is the voltage of the battery. Meters E and G indicate 24 volts, which is the amount of voltage drop across each of the light bulbs. Meter H indicates 18 volts, the voltage drop across the motor. This leaves 6 volts indicated on meter B. Meters C and F indicate zero volts, because there is no voltage drop between the test leads. If there were a broken wire between the switch and the fixed resistor, H and B would read zero. All other meters would read the same as shown.

Notice that meter A indicates zero. This is true because there is no voltage drop across the switch. If this switch were opened, meter A would indicate a voltage drop of approximately 24 volts. With meter A removed, meters B and H would indicate zero voltage. These same indications would result for an opened circuit breaker. An open in an electrical wire will give approximately source voltage when a meter is placed across an open. You may be wondering why there is a 24-volt indication across an open. You may wonder especially when a motor and resistor are in series with an open. When there is an open in a circuit, there is no current flow. The entire circuit on one side of the open will have the same voltage as the battery terminal to which it is connected. The entire circuit on the other side of the open will have the voltage of the other battery terminal. There is a 24-volt difference between battery terminals, so there is a 24-volt difference across the open also.

Setting Up the Multimeter for Ohmmeter Checks. Refer again to figure 4-1. When the function switch is set on OHMS STD, the meter pointer is referenced to the top scale. Resistance values are expressed in ohms. The resistance scale may seem confusing at first because it reads just backward from the other scales. However, a little time spent studying the scale will clarify this matter. When there are many ohms of resistance, only a little current will pass. This causes only a small movement of the pointer. When setting up the multimeter for ohmmeter checks, you first set the function switch to OHMS STD. Next, set the range switch to the value you estimate is enough to cover the resistance in the circuit. Remember, RX is the resistance times the value selected. (This information can be obtained from the applicable technical order.) Next, insert the test leads into the input jacks. Touch the test leads together so you can zero the meter. Gradually rotate the OHMS ADJ knob until the pointer lines up with the zero mark on the resistance scale. After zeroing the meter, you are ready to make your ohmmeter checks.

When checking resistance with an ohmmeter, be sure the component is disconnected from the electrical system.

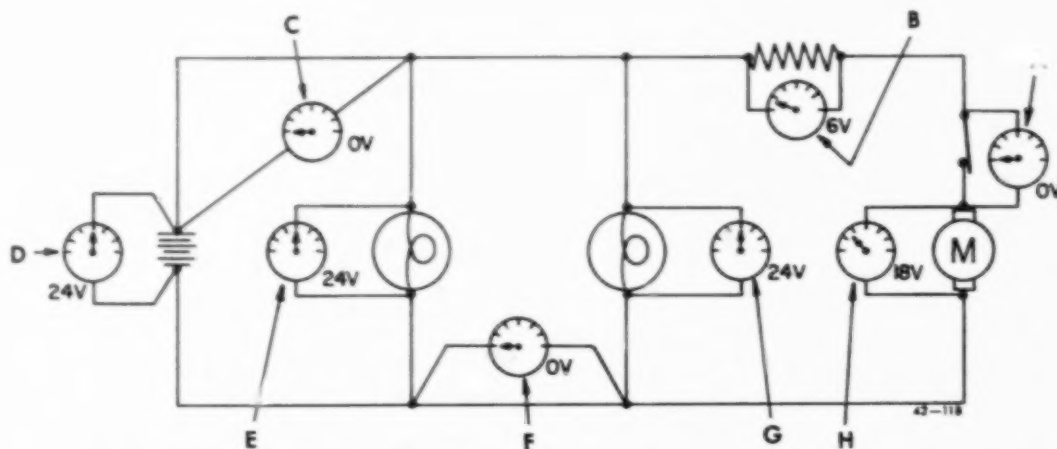


Figure 4-2. Voltage indication, series-parallel circuit.

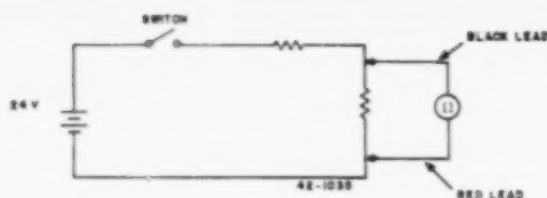


Figure 4-3. Checking for ohms.

Connection of the ohmmeter to a hot system could damage the meter.

Using an ohmmeter to check components for internal opens or shorts. When using an ohmmeter, place one test lead, see figure 4-3, at the component terminal where the voltage supply wire could connect. Place the other test lead to the component's ground terminal. The meter now should give some sort of reading, depending on the amount of internal resistance of the component. A reading of infinity at this point indicates an open caused by a broken wire, excessive corrosion, or an extremely loose connection. Conversely, a complete short shows up as a zero reading. If the resistor that the ohmmeter is connected to is rated at 12 ohms, then the meter should indicate 12 ohms resistance.

Using an ohmmeter to check components for short between the internal circuit and the component case. Apply one lead to the case of the component, and the other lead to each of the terminals except the ground. In this condition, a reading of infinity indicates that the internal circuit is not grounded out internally. However, a reading of anything other than infinity shows that the internal circuit is grounded out against the case. This may be due to not enough clearance between metal parts and the case, or to broken insulation.

Setting Up the Multimeter for Amperage Checks. Current measurements are made by placing the function switch to MA PULSE MA and the range switch to the desired position. When measuring current of an unknown value, always place the range switch in the highest possible position (1000). Remember to turn the polarity switch to the desired DC +, DC -, or AC position. When a current indication is obtained, gradually reduce the range of the meter. One thing to remember, the most accurate

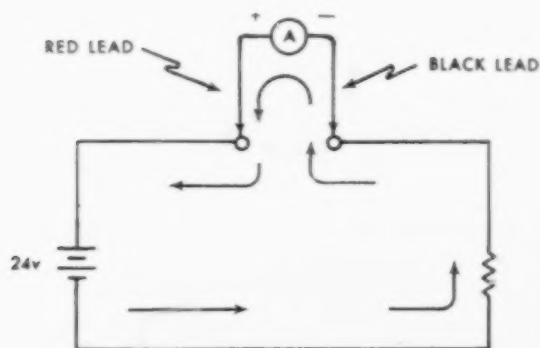


Figure 4-4. Ammeter connected in a circuit.

reading is obtained at the center of the scale, using the lowest possible range. This reading is taken from the AC and DC scale.

Figure 4-4 illustrates the manner in which an ammeter is connected in a circuit. In order to measure current accurately, the meter must be connected in series in the circuit. The conducting path must be broken, and the meter is used to replace the missing part of the circuit. All current in the circuit must pass through the meter.

In summary, let's take a look at the safety precautions that you must observe when you are using PSM-37 to test circuits.

- (1) Never handle the PSM-37 carelessly.
- (2) When measuring unknown voltage and current, start your check with the range set on 1000. Then move it to a lower setting if necessary.
- (3) Never connect the ohmmeter to a circuit that has power on it.
- (4) When used as a voltmeter, connect it in parallel with the voltage drop being checked.
- (5) When you use the meter as an ammeter, connect it in series with the portion of the circuit being checked.

Exercises (250):

1. With the function switch at OHMS STD and range switch at Rx1000, what would the resistance be if the meter needle indicates 20?
2. What will the meter read with the polarity switch on DC, the function switch at MA PULSE MA, the range switch was at 250 and the meter needle at the 1.5 indication?
3. What is the OHM ADJ knob used for?
4. How is the multimeter connected to a circuit when checking amperage?
5. With the meter set for DC voltage, if the function switch is set at 10M, the range switch is at 50, and the pointer points to the 4, what is the voltage indication?
6. When checking electrical resistance with the multimeter, what could happen if the electrical power was not disconnected?
7. With the meter set up for the AC voltage and the function switch at 1KΩ/V, and the range switch to 250, what is the voltage when the needle reads 2?



42-1827

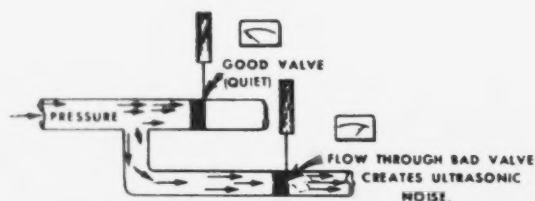
Figure 4-5. Ultrasonic leak detector.

8. How would you set the multimeter to measure the voltage in a 24 volt DC circuit?
9. When checking resistance and the meter needle shows 0, what does this indicate?
10. How would you set up the multimeter to measure 3000Ω of resistance?

251. Specify the use and operational characteristics of an ultrasonic leak detector in locating pneumatic and hydraulic fluid leaks.

Ultrasonic Leak Detector. For many years the most common procedure for detecting leaks in pneumatic systems has been the use of the soap leak test. However, this method is slow, tedious, and expensive, both in man-hours and equipment.

The application of soapsuds requires the operator have a basic knowledge of possible leak locations. Experience has shown that soap testing is generally limited to fittings, valves, and other obvious areas. In practice, however, leaks are often found in unexpected places, such as a



42-1820

Figure 4-6. Detecting internal leakage.

pinhole in a long tube. In some instances, it is impossible to closely observe the formation of soap bubbles over a leak.

Because of these known obstacles and the undesirable extra expense, the Air Force has procured the ultrasonic translator leak detector. If this detector is used correctly, it can save you time and equipment. (We commonly drop the word "translator" in the nomenclature).

Notice in figure 4-5 that the detector has four fasteners that secure the lid on the detector. The lid, not shown, has a compartment for storing the sensing probe and earphones. The detector has the following components and controls: (1) the sensing probe that senses the sound of an air leak, and converts this sound into an electrical signal; (2) two amplifiers that amplify the sensing probe signal and convert this signal into visual and audio signals; (3) a speaker that projects the audio signal (located on the upper half of the tester); (4) an ON-OFF switch that applies internal battery power to the tester circuit; (5) a volume control knob used for controlling circuitry sensitivity; (6) an indicator that visually gives the pressure of a leak by its pointer's clockwise deflection; and (7)

two electrical jacks, one for connecting a tape recorder, and the other for connecting earphones.

Unless you are using the tester in a noisy area, you will probably not use the earphones. To operate the unit, connect the sensing probe and turn the ON-OFF switch. Observe the indicator for slight pointer deflection. After the indicator pointer stabilizes, use the volume control and zero the indicator's pointer. Pointer zeroing eliminates indication of surrounding noises. Now the tester is ready for use.

To use the tester, move the sensing probe slowly over the suspected leak area. The sensing probe should be held in a perpendicular position about 6 inches from the item being tested. As the sensing probe approaches the leak area, it picks up the sound of the leak, and the speaker starts giving out the highly amplified sounds. At the same time, the indicator pointer starts deflecting to indicate the presence of a leak. Both the speaker sound and indicator pointer movement are greatest when the sensing probe is immediately over the leak. As the sensing probe is moved away from the leak, both the speaker and indicator pointer have less output. If earphones are plugged in, the speaker is inoperative. The recorder jack may be used to connect a tape recorder to record the leak sounds for later use.

The ultrasonic detector can save many maintenance man-hours when used to its full capability. For example, in locating a leak in pneumatic system, the probe can be run along the outside of the aircraft skin to pinpoint the general area of the leak without removing numerous panels. This detector can also be used to locate units that are bypassing fluid flow internally. (See figure 4-6). By placing the probe against a suspected valve, you can determine (by sound level and needle

- 245 - 7. A. 0.4690.
B. 0.4697.
- 246 - 1. Breakaway torque wrench.
246 - 2. By turning the grip counterclockwise.
246 - 3. 60 days.
246 - 4. Lowest setting.
246 - 5. In foot-pounds or inch-pounds.
246 - 6. A color coded tape is attached to the torque wrench.
246 - 7. It should be rechecked for accuracy.
- 247 - 1. 80 inch-pounds.
247 - 2. 60 inch-pounds.
247 - 3. 25 foot-pounds.
- 248 - 1. T.
248 - 2. T.
248 - 3. F. More than likely it will be manufactured locally.
248 - 4. T.
248 - 5. T.
248 - 6. F. It can be made out of iron steel, but is usually made out of brass or aluminum.
248 - 7. T.
- 249 - 1. Precision measurement equipment laborator (PMEL).
249 - 2. Make sure that it is all there and in serviceable condition.
249 - 3. Verification is checking for accuracy, while calibration is the actual adjustment.
249 - 4. In the 33 category TOs.
249 - 5. AF Form 1297, Temporary Issue Receipt.
249 - 6. It will indicate if authorized personnel has tried to adjust equipment.
249 - 7. AFTO Form 27, User Certification Label.

CHAPTER 4

- 250 - 1. 20,000 ohms.
250 - 2. 150 milliamps.
250 - 3. To zero the ohms scale because of age and use of the battery.
250 - 4. The meter must be connected in series with the circuit.
250 - 5. 40 volts DC.
250 - 6. The meter could be damaged.
250 - 7. 200 volts AC.
250 - 8. The polarity switch to DC + or -, FUNCTION switch to 20K Ω /v or 1K Ω /v, and the range switch to 50 volts.
250 - 9. A complete short.
250 - 10. The polarity switch to DC + or -, the function switch to OHMS STD, and the range switch to Rx100.
- 251 - 1. When working in a noisy area.
251 - 2. Pointer zeroing eliminates indications of surrounding noises.
251 - 3. The sensing probe picks up the noise of a leak and converts it into an electrical signal.
251 - 4. When you are immediately over the leak.
251 - 5. It can indicate the general area of a leak, thus eliminating pulling unnecessary panels.
- 252 - 1. Wing and axle.
252 - 2. The reservoir and pump.
252 - 3. It prevents accidental lowering of the jack.
252 - 4. a. To prevent a vacuum from being formed as fluid is being withdrawn.
b. To prevent thermal expansion from building up when the jack is under a load.
c. To prevent a buildup of pressure in the reservoir as the jack is being lowered.
- 252 - 5. Release the ram lock and open the needle valve.
252 - 6. The type of aircraft and job to be done.
252 - 7. So it will remain on top of the cylinder in case the ram should accidentally lower.
- 253 - 1. Parallel; perpendicular.

- 253 - 2. To make it easier to get the jack from beneath the aircraft.
253 - 3. To permit the use of one jack for a variety of aircraft.
253 - 4. MA-1 manifold cart.
253 - 5. One man on each jack plus a point man who stands out in front of the aircraft directing the jacking operation.
- 254 - 1. Base assembly, upper structure, and platform.
254 - 2. B-1, B-2, B-4, B-5, and C-1.
254 - 3. The upper structure of the B-2 maintenance stand is almost identical to the B-1 maintenance stand.
254 - 4. A U-shaped steel device which fits into grooves in cylinder assembly.
254 - 5. a. B-1—3-10 feet.
b. B-2—13-20 feet.
c. B-4—3-7 feet.
d. B-5—7-12 feet.
e. C-1—4 feet.
254 - 6. C-1.
254 - 7. To provide working platforms.
254 - 8. a. Reservoir.
b. Hand pump.
c. Cylinder.
d. Shutoff valve.
254 - 9. It should never be raised or lowered while standing on the ladder.
254 - 10. Crew chief.
254 - 11. It can be used independently or installed on the B-1 or B-2 stands.
254 - 12. For performing maintenance work or inspections on systems and components high above the ground.
- 255 - 1. To service the high-pressure air or nitrogen system of aircraft.
255 - 2. Cam lever valves.
255 - 3. Move the trailer closer to the aircraft.
255 - 4. Only one.
255 - 5. To indicate the pressure to the regulator and the amount of pressure leaving.
255 - 6. To bleed any trapped nitrogen pressure from the hose.
255 - 7. It should be blown out.
255 - 8. The one with the lowest pressure but higher than you need to service the aircraft.
255 - 9. Counterclockwise.
255 - 10. To eliminate moisture and foreign material from the nitrogen.
- 256 - 1. It will filter the fluid from the servicing cart.
256 - 2. Check valve.
256 - 3. In the hose storage compartment.
256 - 4. It will return to the reservoir.
256 - 5. Use the large volume pump.
256 - 6. To prevent dirt from entering the hose.

CHAPTER 5

- 257 - 1. To purge the air from the system prior to test stand operation.
257 - 2. 24-volt DC motor.
257 - 3. The filters are good.
257 - 4. Only system #2 will fill.
257 - 5. When the fill pump switch is placed to the ON position.
257 - 6. To check for leaks.
257 - 7. You must repeat the pressurizing and bleeding operation until a solid column of fluid can be seen in the sight tube.
257 - 8. No pressure will be developed and the system will not fill.
- 258 - 1. Sliding vane rotary pump.
258 - 2. Supply fluid to the main pump.
258 - 3. Test stand engine.
258 - 4. The thermal relief valve prevents the build up of pressure due to expansion of the fluid after shutdown.
258 - 5. Pressure is regulated by the low-pressure relief valve.
258 - 6. From the stand reservoir.
258 - 7. If the temperature of the fluid rises to high.

- 258 - 8. The test stand will shut down.
 258 - 9. It prevents the flow of low-pressure fluid back to the boost pump.
 258 - 10. By visually observing the fluid passing through the sight tube.
- 259 - 1. The high-pressure system provides fluid at a controlled volume and pressure to the aircraft for ground testing and maintenance of the aircraft hydraulic system.
 259 - 2. The high-pressure pump is a variable volume pump.
 259 - 3. The pressure compensator automatically controls pump output and compensates for changes in pressure.
 259 - 4. 3 gallons per minute.
 259 - 5. The pump is lubricated by the fluid it pumps.
 259 - 6. With the bypass through flowmeter valve open, the pump output is bypassed back to the boost pump. This results in no output pressure from the HP pump. The compensator cannot be adjusted unless the pump is capable of establishing an output pressure.
 259 - 7. By pressure and return hoses.
 259 - 8. The bypass valve must be closed and the flow control valve must be open.
- 260 - 1. He should immediately open the bypass through cooler valve.
 260 - 2. When both valves are closed, there is a strong possibility that back pressure in the lines will rupture them, thereby endangering both the equipment and the operator.
 260 - 3. As the fluid passes through the cooler, the heat is transferred to the cooling fins and is dissipated by air from the cooling fins.
 260 - 4. The return line is low pressure which permits the use of a glass flowmeter. Since the hydraulic system is completely inclosed, the volume of fluid returning is equivalent to the volume being delivered.
 260 - 5. The compressor is driven by a V-belt from the cooling fan shaft.
 260 - 6. Pressurization reduces foaming in the reservoir.
 260 - 7. The pilot unloader valve.
- 261 - 1. The maintenance forms.
 261 - 2. The hoses and quick disconnects.
 261 - 3. Three: engine oil, gear case oil, and air compressor oil.
 261 - 4. The valves are checked for freedom of movement, looseness, and signs of leakage.
 261 - 5. a. Exterior of test stand.
 b. Interior of test stand.
 c. Instrument and control panel.
 d. Hoses and quick disconnect.
- 262 - 1. Lines may rupture causing high-pressure fluid to be injected into eyes and skin.
- 262 - 2. The controls are identical but reversed in their location.
 262 - 3. One behind each sight tube and flowmeter.
 262 - 4. It must be in the external position.
 262 - 5. The compensator will control pressure at its own setting. If it is not initially set above relief setting, the pressure will remain at the compensator setting.
 262 - 6. It will engage the desired system pump to the test stands engine.
 262 - 7. If the temperature of the fluid approached the red area on the gauge, the bypass valve should be opened. This will allow the fluid to pass through the cooler.
 262 - 8. The test stand should be shut down at once.
- 263 - 1. It is an oil bath air cleaner.
 263 - 2. The intercoolers and aftercooler remove the heat caused by compression of the air.
 263 - 3. The separator, separates the moisture from the air.
 263 - 4. The unloader valve assembly.
 263 - 5. a. When the compressor oil pressure decreased below 15 psi.
 b. If air pressure exceeds the pressure switch setting.
 c. If the normal drain switch is positioned to unload.
 263 - 6. Because the pressure in each stage of compression is different.
 263 - 7. The dehydrator absorbs moisture in the compressed air which was not removed by the separators.
 263 - 8. To the 10-micron filter.
 263 - 9. The priority valve set at 2400 psig insures maximum effectiveness of the dehydrators.
- 264 - 1. a. (6).
 b. (5).
 c. (4).
 d. (3).
 e. (2).
 f. (1).
 g. (5).
- 265 - 1. a. 5.
 b. 8.
 c. 3.
 d. 4.
 e. 6.
 f. 1.
 g. 2.
 h. 7.
- 266 - 1. The MD-3 is used to start aircraft and for performing operational checks of the system.
 266 - 2. 28-volt DC and 115-200-volt, three-phase, 400-Hz AC electrical power.

42354 00 S01 8006

CHANGE SUPPLEMENT

CDC 42354

AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC

(AFSC 42354)

Volumes 1, 2, 3 and 4

IMPORTANT: Make the corrections indicated in this supplement before beginning study of Volumes 1, 2, 3 and 4. This supplement contains both "pen-and-ink" changes and replacement pages. It is three-hole-punched so you can tear out the replacement pages and insert them in your volumes.

You are not required to post any changes listed in this supplement which correct typographical errors, unless such errors change or otherwise affect the meaning of the material.

CHANGES FOR THE TEXT: VOLUME 1

PEN-AND-INK CHANGES:

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
1L		22 from bottom	After "having" delete "e."
2R		21	Change "you" to "your."
2	Exercises (001)-2		Question 2 is duplicated. Delete one of them.
10R		6	Change "knw" to "know."
11L		7	After "in" insert "and."
11R		25	Change "when" to "whom."
13R		17 from bottom	Change "an" to "on."
15L		3 from bottom	After "may" change "e" to "be."
18R		20 from bottom	Change "conver" to "cover."
28L		13 from bottom	Duplication - delete "one of . . . security program."
30R		19-20	Duplication - delete "Instead, such . . . not so,".
30R		9 from bottom	After "difficulty" insert "The telephone may not use a."
30R		8 from bottom	Delete "no."
34L		10	Between lines 10 and 11, insert "● Overt-activities conducted openly."
38	Exercises (023)-2		Change "the" to "that" and change "collecors" to "collectors."
44L		9 from bottom	Duplication - delete "current in the."
44L		5 from bottom	Change "load" to "loan."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
47L		9-11	Duplication - delete "The Letter . . . or Vacuum."
47	Exercises (031)-1		Change "is" to "in."
48R		4	Duplication - delete "of categories."
52L		3	Change "39" to "3-9."
54L		3 from bottom	After the dash in the parenthesis, insert "1."
55R		15	After "The" insert "complete number for."
55R		16	Delete "take one."
55R		33-34	Duplication - delete "The M . . . the title."
57L		11	Change "lubricated in" to "lubricated if."
63L		2	Change "this" to "This."
63	Exercises (036)		Under "Column A Information" the fourth item down should be number "4" instead of "3."
65R		22	Change "can" to "and."
68R		6	Change "not" to "no."
72R		2	Delete "does."
78	Exercises (043)-7		Change "received" to "removed."
81L		24 from bottom	Change "is" to "in."
81L		10 from bottom	Change "effor" to "effort."
82R		27 from bottom	After "Part number" delete "or."
89	Exercises (048)-4		Delete the question.

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
89	Exercises (048)-6		Delete the question.
90L		12 from bottom	Change "had" to "hand."
98	Exercises (053)-10.c.		Duplication - delete first "10.c."
99L		18 from bottom	Change "(001-366)" to "(001-0365)."
122R		26	Change "withd" to "with."
124L		18 from bottom	Change "suervision" to "supervision."
128L		11	Duplication - delete "or even supervisor."
129	Figure 6-4		In the "IN SHOP REPAIR" block, change "REPAIN" to "REPAIR."
145L		12	Duplication - delete "grasp . . . extinguisher."
161	Answer 001-2		Answers miskeyed. Change to read: "a. 5 b. 1 c. 3, 6 d. 4."
161	Answer 002-5		Change " <i>manual</i> " to " <i>regulation</i> ."
161	Answer 005-5		Change "6" to "20."
162	Answers 012-2, 3 & 4		Delete answers.
164	Answer 041-2.e		Change "T" to "F."
164	Answers 048-4 and 6		Delete answers.
167	Answer 066-3		Change "Maintenance" to "Job."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
167	Answer 068-2		Delete.
167	Answers 069-5 & 6		Delete "069 - " in front of answers 5 and 6.
167	Answer 069-6	7-8	Duplication - delete "a qualification . . . individual has."
168	Answer 078-4		Between "waiting" and "the" insert "until."
168	Answer 079-3		Change "Two" to "Three."
168	Answer 083-2		Change "complainer" to "counselee."
169	Answer 089-5		Between "and" and "excessive" insert "away from."
169	Answer 090-2		Delete "090 - " in front of answer.
169	Answer 092-3		Delete "092 - " in front of answer.
169	Answer 094-1		Before "Radar" insert "b."
170	Answer 098-2		Place the "2." in line with other answers.
170	Answer 099-2		Answer "2." should be placed in line with other answers.
170	Answer 099-3		Delete "099 - " in front of answer 3.

REPLACEMENT PAGES: Insert the following replacement pages: 107, 108, 109,
110, 111, 112, 113, 113a, 114, 165, 166 and 166a.

1. DATE 10/01/4		2. CREW CHIEF C. Padgett SSGT		3. ORGANIZATION 437 MAW		4. LOCATION CHARLSTON AFB S.C.		5. MDS C-141A		6. SERIAL NUMBER 66-230	
7. STATUS OF OVERDUE IN-PROGRESS AND ACCOMPLISHED INSPECTIONS INCLUDING FCIS						8. CERTIFICATION FOR ACCOMPLISHMENT OF BASIC POSTFLIGHT OR THRUFLIGHT					
TYPE	SYM	SYSTEM	ACCOMPLISHED BY	COMPLETED DATE	TIME	FLT NO	TYPE INSP.	ACCOMPLISHED BY	COMPLETED DATE	TIME	
PR	P	03(ACFT + ENG)	C. PADGETT SSGT.	10/01/4	05:30	1	BPO	B. HUDSON SSGT.	10/01/4	14:20	
				/ /	:	2			/ /	:	
				/ /	:	3			/ /	:	
				/ /	:	4			/ /	:	
				/ /	:	5			/ /	:	
				/ /	:	6			/ /	:	

9. STATUS DATA						10. FLIGHT CONDITION DATA					
SEE BLOCK 7 AND AFTO FORMS 781A AND 781E FOR EXPLANATION OF THE STATUS SYMBOL	STATUS TODAY	BOX NO	EXCEPTIONAL RELEASE (Enter Box No.)	FLT NO	COND AFT FLT	PILOT'S SIGNATURE ENTER AFTER EACH FLIGHT				Over Temp Enclrd	Aux Engine or APU Operation
	7	3	C.A. LOWMAN 2LT. (MO)	1							
	8			2							
	9			3							
	10			4							
	11			5							
	12			6							

11. MUNITIONS/GUNS STATUS												12. SERVICING DATA													
STATUS 781A ENTRY												FUEL (Gallons or Pounds) ENG OIL (Gallons, Quarts, or Gallons) CSD													
OCTANE OR GRADE		QUANTITY SERVICED		TOTAL IN TANKS		1		2		3		4		F1		F2		F3		F4		OXY PRESS OR QTY		APIV	
						SER IN		SER IN		SER IN		SER IN		SER IN		SER IN		SER IN		SER IN					
1. JP-4		—		70,000		0 24		0 24		0 24		0 24		0 10		0 10		0 10		0 10		17 100		0 4	
2. JP-4		20,000		90,000		0 24		0 24		0 24		0 24		0 10		0 10		0 10		0 10		17 100		0 4	

13. SERVICING CERTIFICATION (Signature, Grade and Station at Which Servicing is Accomplished)											
1 BY J. Anderson Sgt Charleston AFB		3 BY		5 BY							
AT		AT		AT							
2 BY J. Anderson Sgt Charleston AFB		4 BY		6 BY							
AT		AT		AT							

14. AIRFRAME TIME		15. LANDINGS		16. CARTRIDGE STARTS		17. ENGINE CYCLE DOCUMENTATION															
PREVIOUS 92145		FULL STOP 2186 TOTAL 8404		NO ENG NO ENG		NO 1 ENG		NO 2 ENG		NO 3 ENG		NO 4 ENG		NO 5 ENG		NO 6 ENG		NO 7 ENG		NO 8 ENG	
1 6.5		1 3				3 3		3 3		3 3											
TOTAL 9221.0		2187 8407																			

AFTO FORM 781H
MAY 73
PREVIOUS EDITION IS OBSOLETE.
U.S. Government Printing Office: 1973 - 759-799/7018 Region 5-11

AEROSPACE VEHICLE FLIGHT STATUS AND MAINTENANCE DOCUMENT

Figure 5-7. AFTO Form 781H.

release is a certification that the authorized individual who enters his signature in this column has investigated defects covered by red symbols and that, in his opinion, the aircraft is safe for flight.

An exceptional release may be granted as a conditional release. For example, the release of an aircraft with defective night flying equipment may include the condition that the aircraft is not to be flown during hours of darkness. When such conditional releases are granted, the conditions of the release will be described by an appropriate entry in the AFTO Form 781A.

Block 10. The Flight Condition Data block is divided into five sections, with provisions for six line entries. This block is used for the pilot to make entries after a flight. If the flight was satisfactory, with no discrepancies, he enters OK in the Cond Aft Flt column. If there were discrepancies, he enters the number of discrepancies in this column. Each discrepancy encountered will also be entered in the AFTO Form 781A.

Block 11. The Munitions/Guns Status blocks or lines are used to record armament status. The status portion is used to indicate whether or not the munitions are hot, cold, or not installed by circling the appropriate symbol in red. The 781A Entry block is used to indicate the page (P) and item (I) in the AFTO Form 781A where this armament configuration is explained. This 781A entry is cleared either by the pilot or the munitions loading chief, depending upon whether the munitions were all expended in flight or were down-loaded after landing.

Block 14. The Airframe Time block is simply a continuous record of flying hours. Six lines are provided to record the number of flights for 1 day. The previous block reflects the total flying hours since the aircraft was new. The crew chief or his representative usually transcribes the flying time from the AFTO Form 781 to this form during the debriefing session and enters the sum of these figures in the Total block. This total is then transcribed to the previous block of the new AFTO Form 781H.

Exercises (059):

Using the AFTO Form 781H shown in figure 5-7, determine the meaning of various entries as follows:

1. What does it mean when a black last name initial is placed in box 1 of block 9?
2. What should be done if an entry is entered in error?
3. What is indicated if a red X is placed in the last open box of block 9?
4. Can an exceptional release be granted for a red X or circled red X?
5. What does it indicate if a pilot places an OK in the Cond Aft Flt column of block 10?
6. What does it mean if a red circle is placed around the word "Hot" in block 11?
7. You get the total aircraft time. Which block would you go to for this?

060. Identify the purpose, use, and how to complete AF Form 1492, Danger Tag.

This form is an important tool in accident prevention. It is used as a warning to maintenance personnel to identify unsafe material or equipment.

AF Form 1492, Danger Tag. This form is attached by designated tag-issuing authorities to material and equipment which are no longer safe for use because of defects, abuse, or wear. The Danger Tag is not intended for use in reporting minor hazards that should be corrected by the responsible supervisor.

Commanders will designate tag-issuing authorities in maintenance, base engineering, supply, safety and other functional activities. Authorized personnel will attach the tag to unsafe machinery, equipment, tools, aircraft systems, valves, and other materials as necessary to prevent injury to personnel or damage to material and equipment.

When you have an unsafe condition, whether it is on an aircraft or in the shop, the tag-issuing authority completes Parts A and B of the AF Form 1492. Unless the item is unsafe mechanically, the Danger Tag is not used on aircraft or equipment that has been contaminated radiologically. The tag is also not to be used for radioactively contaminated equipment or for ammunition or explosive materials.

Once Parts A and B of the Danger Tag have been filled out by the tag-issuing authority, Part A is then attached to the unsafe system switches, components, circuit breakers, etc. This is done so that other personnel will know that a piece of equipment is unsafe for use because of a defect in the system. Then, Part B of the Danger Tag is torn off for use in correcting the condition. Part B can be placed in the aircraft's 781A forms, given to the dock chief, or otherwise disposed of as local policy states. An example for completing AF Form 1492 is shown in figure 5-8.

Note how the following sections are completed:

a. Tag Number: 1 of 6 filled in on Parts A and B (which means that this is tag 1 of 6 that were issued for this danger condition).

b. Date: Filled in on Parts A and B.

c. Location: Location of Part A of AF Form 1492 is filled in on Parts A and B.

d. Condition: Indicate here what is wrong with the equipment.

e. Signature: Signature of the tag-issuing authority.

f. Title: NCOIC Hydraulic Shop, etc.

g. Phone and Extension: Phone number where tag-issuing authority can be reached.

h. Corrective action taken and by whom the action was completed. Each commander will establish procedures for corrective action to insure prompt follow-up action and to insure elimination of the unsafe condition. Part B of AF Form 1492 can be used

as a priority flag on the work order requesting replacement or the issue of new equipment or parts.

Once the condition has been fixed, only the tag-issuing authority or the designated representative may remove Part A of the tag. The tag-issuing authority will remove Part A only when, in their opinion, the unsafe condition has been corrected, or the unsafe material or equipment has been removed permanently from service in accordance with AFM 67-1 or the appropriate technical order.

Exercises (060):

1. What is the basic purpose of the AF Form 1492 Danger Tag?
2. Who designates the tag-issuing authority?
3. Under what condition is AF Form 1492 not to be used?
4. Once a Danger Tag is issued, what happens to Part A of the form?
5. Who is authorized to remove Part A of the Danger Tag after the unsafe condition is corrected?

061. Clarify the AFTO Forms 244 and 245 by giving the purpose of each and discussing selected entries that are recorded on them.

AFTO Form 244. The AFTO Form 244 provides a means of documenting equipment discrepancies and corrective action. This form is also used for recording service inspections, periodic and special inspection status, and historical data. This AFTO form is used to provide the operator and the repairman with a record of the current status of the unit. A sample of AFTO Form 244 is shown in figure 5-9. Study the figure as we proceed.

Begin your review of the maintenance of AFTO Form 244 by checking Part I. This part provides a means of identifying the equipment and contains eight blocks of information. The first block in Part I is used to identify the end item by its name and type or model.

In Blocks 2 and 3, you would enter the end item registration number for registered AGE or the serial number for nonregistered AGE and trainers. The ID number is used on all AFTO Forms 349 and 350 for maintenance actions against the unit. When a field number is assigned to a unit, enter this number in Block 4.

The work unit code assigned to the item is recorded in Block 5. This code is found in the -06 manual for AGE, and it aids the repairman in finding the subcodes needed for his maintenance forms. If the incorrect work unit code and subcodes are used on the maintenance forms, you'll have errors in the maintenance data collection system. This, in turn, will give AFLC incorrect information in the maintenance data statistical reports. Therefore, it is necessary that the correct work unit code be used on all maintenance forms.

In Block 6, enter the workcenter of the owning organization. Record in Block 7 (Period Cover), on the left half of the block, the date on which the form was initiated. The date entered on the right half of the block is the date the form is closed out and a new form is initiated or the equipment is turned into supply or salvage.

Part II, of the AFTO Form 244, provides a means of documenting the required service inspections. Enter the time, date, and the initials of the person completing the inspection. Part III informs you which type of inspection is due and at what intervals the inspection will be completed. These inspections include Periodic, 30-Day, Special, or Yearly, etc. In the Date Due and Completed column,

enter the date the inspection is due. Once the required inspection is completed, the individual initials the appropriate column and writes in the date of the completed inspection.

Supervisory Review Part IV provides a means of documenting a supervisory inspection of the system or equipment forms. The supervisor enters the employee number and the date in the block provided when the inspection is completed. Any and all discrepancies discovered are recorded in Part V or on AFTO Form 245 (Part V Continuation Form).

Part V and AFTO Form 245. The AFTO Form 244, Part V, shown in figure 5-10, is the maintenance delayed discrepancy record. The AFTO Form 245 is a continuation form that is used when Part V of the AFTO Form 244 has been filled with discrepancies. They are used to provide a continuous record of all maintenance, both minor and major, that has been completed on the unit. They also provide a record of any uncleared discrepancies that may affect unit operation. Part V and AFTO 245, Maintenance/Delayed Discrepancy, is the section of the form pertinent to the flight-line mechanic. It is in this section that entries are made by the user as they are discovered.

Suppose a unit was dispatched to the flightline with a red X entered in Part V or the AFTO Form 245. Then a flightline mechanic who is in a hurry doesn't check the forms for the status of the unit. Not knowing that the unit is on a red X, he tries to start it. Immediately things will begin to happen; the unit may even come apart or catch on fire. Either result can cause injury to the mechanic or the possible loss of a million dollar aircraft. Therefore, it is important that you check the forms for all discrepancies to insure that the unit is safe for operation.

From the information which we have discussed in the previous objective of this course, Part V and AFTO Form 245, Maintenance/Delayed Discrepancy,

FORM 1492
AF JUL 63

PREVIOUS EDITIONS
OF THIS FORM WILL
BE USED UNTIL
STOCK IS EXHAUSTED

PART A

DANGER
DO NOT USE OR OPERATE

TAG NUMBER	1 of 6	DATE	14 Oct 76
LOCATION	Ext. POWER RECP.		
CONDITION	Open Fuel Line		
IFR Boom AREA			
SIGNATURE			
Small M Duckworth MSgt			
TITLE			
NCOIC Hyd Shop			
PHONE	2889	EXTENSION	
CORRECTIVE ACTION TAKEN			
BY:			
DATE	TAG NUMBER	PART B	
14 Oct 76	1 of 6		
LOCATION	Ext. POWER RECP.		
CONDITION	Open Fuel line		
IFR Boom Area			

DANGER

DO NOT USE OR OPER-
ATE THIS EQUIPMENT
UNTIL UNSAFE CONDI-
TION CITED ON REVERSE
SIDE HAS BEEN CORREC-
TED AND AFM 127-101 HAS
BEEN COMPLIED WITH.

Figure 5-8. AF Form 1492.

[illegible][illegible]

Figure 5-9. AFTO Form 244.

12

[illegible]

should be self-explanatory. To show you how simple this form is to use, we will simulate a situation in which you might become involved. Let's say that you have been operating a hydraulic test stand and it develops a hydraulic leak. Look at fig. 5-10 while we talk about placing an entry on the forms. Under the Date Discovered column, enter the employee number of the individual that discovered the discrepancy. In the Symbol column, enter the applicable status symbol for the discrepancy. In the Discrepancy column, enter the discrepancy or maintenance action required. This entry should reflect the same description that appears on the associated AFTO Form 349. Remember, only one defect will be entered in each block for each job control number; however, use as many blocks as necessary to completely describe the discrepancy. In this case, the discrepancy would read something like this: Hydraulic leak from pressure line at hydraulic pump.

The AFTO Form 244 will be closed out and a new form will be initiated whenever additional recording space is required in Parts II and III. The person closing out the form will make the following entries: Block 7, enter the close-out date in the right half of the Period Cover block. Carry forward any open inspection items in Part III to the new form. For Part V and AFTO Form 245, carry forward any open discrepancies to the new form. The old form is then placed in the historical records and retained as a permanent part of the equipment records.

Exercises (061):

1. What is the purpose of AFTO Form 244?
2. How would you determine the status of a piece of equipment using the AFTO Form 244?
3. What purpose does the AFTO Form 245 serve?
4. Once an AFTO Form 244 has been closed out, what happens to the form?

062. Concerning the materiel deficiency reporting system, state its purpose and, given hypothetical situations, identify the report category in each such situation.

Materiel Deficiency Report. The purpose of the materiel deficiency reporting system is to provide data to activities who are responsible for development, procurement, and other logistics management functions. If warranted, this data is then used to initiate action to correct materiel

design and prevent quality deficiencies. In other words, included here are those materials which do not conform with applicable specifications, drawings, standards, etc. Also, included here are errors in workmanship either during manufacture, repair, modification, or maintenance.

The maintenance data collection system is the primary source of data. It is therefore the principle source of materiel deficiency information.

Step-by-step procedures and instructions for reporting materiel deficiencies are outlined in TO 00-35D-54, *USAF Materiel Deficiency Reporting and Investigating System*. This TO should be consulted whenever questions arise concerning materiel deficiency reports.

Reporting procedures are broken down into two categories: Category I and category II reports.

Category I Reports. Category I reports are concerned with emergency conditions pertaining to safety on all types of equipment. Emergency conditions are defined as:

a. Accident or incident—any event that does damage, or could cause damage, to persons or property, excluding enemy action.

b. Nuclear safety deficiency—any deficiency which could cause, or contribute to, a nuclear accident or incident.

c. Critical safety deficiency—the malfunction of a part, component, or installation which creates a hazard that must be corrected as soon as possible for personnel and systems survival.

d. For aircraft—any materiel or installation deficiency which requires inflight emergency procedures to avert further damage or injury to personnel.

Other conditions are described in TO 00-35D-54.

Category I reports are submitted by electrical transmission to Air Logistics Command (ALC), where they generate investigation projects. These projects are given the highest priority available. Category I reports require continuous (around the clock) action for a solution.

Category II reports. These reports are used to report design and maintenance materiel deficiencies of non-work-coded items. These deficiencies do not have a safety impact, but if left uncorrected they could:

- a. Create a safety hazard.
- b. Have a negative effect on operational effectiveness.
- c. Reduce tactical or tactical supportability.
- d. Reduce operational life or general service utilization of equipment.
- e. Create economic burdens (both manpower and money).

Category II reports are submitted to ALC by automatic digital network (AUTODIN). Other

materials, such as photographs, go by airmail. These reports receive a lower priority investigation than do priority I reports.

The person discovering the deficiency will prepare, process, and route materiel deficiency reports as prescribed in TO 00-35D-54. The Deputy Commander for Maintenance of the submitting activity will review all materiel deficiency reports prior to submittal to insure that they are reported correctly and properly routed. The safety office should also be informed of accidents or incidents where damage or injury results from materiel deficiencies.

Materiel deficiency exhibits. Materiel deficiency exhibits will be held by quality control (or base supply when storage facilities are not available) or as designated by the major command. Storage should be a secure, minimum-access—preferably locked—area to insure that the exhibit is not altered or lost. Exhibits, if shipped, should go by priority methods, such as airlift, airmail, or express.

NOTE: Under no condition will any disassembly or repair be accomplished on the exhibit by field activities. When directed the item will be forwarded in the exact condition as it was when found deficient. All exhibits will be identified with an AFTO Form 114, Materiel Deficiency Exhibit Tag, attached to the exhibit, and also to the outside of the container near the address label. For this, see figure 5-11.

Exercises (062):

1. While inspecting the aileron control system during the acceptance inspection of a new aircraft, you discover that the aileron will not go to the full up position. Further investigation reveals that the aileron control valve binds because the mount bracket is not positioned properly. Which materiel deficiency report category would be used to report this condition? Explain why briefly.
2. Which category deficiency report would be submitted to correct a condition on an aircraft which would not involve personnel or equipment safety?
3. Which tag will be attached to a materiel deficiency exhibit?
4. What is the purpose of the materiel deficiency reporting system?

- 052 - 1. a. On-equipment.
b. Off-equipment.
c. Productive indirect.
2. Time compliance technical order (TCTO).
3. Coded information is used to simplify data recording, to standardize documentation, and to reduce writing time for the maintenance personnel. It also simplifies data retrieval.

- 053 - 1. Block 3.

2. Maintenance control.
3. When it is used as a dispatch form.
4. The time that the work is scheduled to start.
5. The estimated clock hours.
6. The NIIN will be used when an item does not have a part number.
7. Column C.
8. Work order number.
9. The mission, design, and series (MDS).
10.

MAINTENANCE DATA COLLECTION RECORD															OMB NO 21-80227		
1. JOB CONTROL NO.		2. WORKCENTER		3. I.D. NO./SERIAL NO.		4. MDS		5. EQ/CL		6. TIME		7. PRI		8. SORTIE NO.		9. LOCATION	
0270012		Q3340		QA3407								2				B7	
10. ENG. TIME		11. ENGR. I.D.		12. INST. ENG. TIME		13. INST. ENL. I.D.		14.		15.		16.		17. TIME NPC REQ		18. JOB STD.	
														0830		3.0	
19. FIC		20. PART NUMBER		21. SER. NO./OPER. TIME		22. TAG NO.		23. INST. ITEM PART NO.		24. SERIAL NUMBER		25. OPER. TIME					
A		B		C		D		E		F		G		H		I	
TYPE MAINT		COMP POS		WORK UNIT CODE		ACTION TAKEN		WHEN DISC		HOW MAL		UNITS		START HOUR		STOP HOUR	
1		B		13221		R		F		381		1		0830		27 1030	
2																	
3																	
4																	
5																	
26. DISCREPANCY																	
Nose Landing Gear Actuator Leaking																	
27. CORRECTIVE ACTION																	
Removed and Replaced Nose Landing Gear Actuator I/A/W IC-130B-2-12 Par 4-32 Fig 4-8																	
28. RECORDS ACTION																	

AFTO FORM 349 MAY 78 PREVIOUS EDITION IS OBSOLETE.

Figure 1. AFTO Form 349 (answer for objective 053, exercise 10).

- 054 - 1. Indirect labor.
2. In the -06 work unit code manuals (see foldout 1, part F).
3. The start and stop time will be entered during normal duty hours.
- 055 - 1. They should be legible in order to reduce errors caused by somebody misinterpreting your writing.
2. First name initial, complete last name, and rank or grade.
3. 15/10/4.
4. Will the reader understand?
- 056 - 1. They represent, in the opinion of the individual making the entry, that certain conditions exist requiring attention that may affect mechanical

- condition, fitness for flight or operation, servicing or inspection of that equipment.
2. Red X, circled red X, red dash, red diagonal, and black last name initial.
3. Never. Once entered, even in error, it must be cleared properly with an adequate explanation in the Corrective action block and signed off.
4. The red X.
5. The circled red X.
6. An unknown condition.
7. The red diagonal.
8. A black last name initial over a red symbol indicates that the condition has been corrected.
9. To make important notations instantly apparent.

- 057 - 1 and 2.

DATE FROM 19/03/4		TO / /		CREW CHIEF S. Black Sgt		ORGN 516 MAWG		LOCATION Dyess AFB Tex		MDS C-130E		SERIAL NO. 66-243	
DATE DISCD 19/03/6		WDC J		JCN 0787550		TAG NO 35320		CF TO 781A DATED P 1 / /		TRANSFERRED TO 781K DATE / /		TRANSFERRED BY	
DISCREPANCY Nose Landing Gear Actuator Leaking								CORRECTIVE ACTION Removed and Replaced Nose Landing Gear actuator I/A/W IC-130B-2-12 Par. 4-32 and Fig 4-8					
DN X103HS60780001		DISCOVERED BY S. Black Sgt						CORRECTED BY F Smith Sgt		INSPECTED BY P. Jones TSgt			
SYM / /		DATE DISCD / /		WDC /		JCN /		TAG NO /		CF TO 781A DATED P 1 / /		TRANSFERRED TO 781K DATE / /	
DISCREPANCY								CORRECTIVE ACTION					
DATE CORRECTED / /								DATE CORRECTED / /					
DN		DISCOVERED BY						CORRECTED BY		INSPECTED BY			

AF TO 781A

MAINTENANCE DISCREPANCY AND WORK DOCUMENT

PREVIOUS EDITION
IS OBSOLETE

Figure 2. AFTO Form 781A (answer for objective 057, exercises 1 and 2).

- 058 - 1. No.
2. The person accomplishing the action will date and sign the Transferred By column. The entry will then be lined out, except for the Date and Signature blocks.
3. The Sys column references the aircraft system to which that discrepancy or entry pertains.
4. This gives additional information about the entry. This kind of information is important during records checks or for other reference purposes.
- 059 - 1. That no defects exist on the aircraft.
2. A symbol entered in error should never be erased; instead it should be explained in the 781A, and a new correct status symbol should be entered in the next open box.
3. That this is the most serious defect that exists on the aircraft and that the aircraft is unfit for flight.
4. Under no conditions.
5. That the flight is satisfactory with no discrepancies.
6. That munitions are installed and armed.
7. Block 14 of the AFTO Form 781H.

- 060 - 1. To identify material and equipment which is no longer safe for use because of defects, abuse or wear.
2. Commanders.
 3. It will not be used on aircraft or equipment that is radio-active or radiologically contaminated unless it is unsafe mechanically.
 4. Part A of the AF Form 1492 is attached to the unsafe system, components, circuit breakers, etc.
 5. The tag-issuing authority or a designated representative may remove Part A when, in their opinion, the unsafe condition has been fixed.
- 061 - 1. To provide a means of documenting inspections, equipment discrepancies and corrective actions.
2. By checking Part V of AFTO Form 244 or AFTO Form 245 for uncleared discrepancies.
 3. As a continuation form for the AFTO Form 244, Part V, Maintenance/Delay Discrepancy.
 4. The old form is then placed in the historical records and retained as a permanent part of the equipment records.
- 062 - 1. Category I, because it involves the flight controls which could cause the aircraft to crash.
2. Category II.
 3. AFTO Form 114.
 4. It provides data which can be used to initiate action to correct materiel design or maintenance error.

CHANGES FOR THE TEXT: VOLUME 2

PEN-AND-INK CHANGES:

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
4R		11 from bottom	Change "know" to "known."
6L		13	On the line before "Mechanical Advantage (MA)." insert "202. From given information determine the MA for various problems."
6L		8 from bottom	Between "distance" and "must" insert "the pistons."
19	Exercises (211)-3		Change "a" to "2."
20L		4	Change "aid" to "aids."
30R		2	After "cure." insert "date."
41L		1-2 from bottom	Change "The nipple hex should bottom against the socket face." to "Maximum allowable gap between nipple hex and socket is 0.060 inch."
52	Exercises (228)-2		Change "An" to "AN."
53L		9-15	The second paragraph should be the third paragraph and the third paragraph should be the second.
53L		23	Change "unit" to "until."
54L		17	Change "cut" to "nut."
55R		2 from bottom	Between the first and second lines from the bottom, insert "Exercises (230):."
73L		6	Change "are" to "can not be."
73	Exercises (240)-4		Between "make" and "erasable" insert "non."
79	Exercises (244)-4		Change "look" to "lock."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
80R		17 from bottom	Change "moe" to "move."
87R		8	After "picture" insert "shows a fixture that can be used to hold an accumulator or actuator during repair. The bottom picture."
88	Exercises (248)-7		Change "jib" to "jig."
94L		17	Change "on" to "one."
111R		18	Change "in" to "is."
113L		7	Delete "(9)".
125R		9	Duplication - delete "All done . . . the battery."
132L		1	Change "allows" to "allow."
132L		6	Delete "and."
141L		10-11	Duplication - delete "the pump . . . 5000 psi."
143L		19 from bottom	Duplication - Change "the the" to "the."
145R		22	Between "back" and "out" delete "to."
146R		25	Between "cutting" and "skiving" insert "and."
150R		5	Between "any" and "destructive" insert "non."
152L		7	Duplication - delete "switch on."
153R		1-last	Delete "6-3. Ultrasonic Filter Cleaning . . . physical. The other is."
154-157			Delete pages.

PAGE-COL	SUBJECT	LINE (S)	CORRECTION
159	Answer 201-5		Under "Column B" change to read: "V = 20 cu in A = 10 sq in L = 2 in."
159	Answer 204-1		Change "100 ft-lbs" to "1000 ft. lbs."
160	Answer 209-1		Change "3 amps" to "4 amps."
162	Answer 231-6		Answer 6 is missing. Insert "231-6. 0.020 steel wire."
162	Answer 238-2.a		Change "T" to "F."
163	Answer 249-6		Delete "authorized."
164	Answer 258-9		Change the second "8." to "9."
165	Answers 275-1 thru 275-6		Delete.
166	Answers 275-7 thru 276-14		Delete.

CHANGES FOR THE TEXT: VOLUME 3

1R		14	Change "non" to "no."
4R		3	Change "sent" to "send."
4R		16	Change "valve" to "value."
5	Exercises (402)-5		Change "refil" to "refill."
6R		22	Change "(puppet)" to "(poppet)."
9L		3 from bottom	Change "metter" to "matter."
11L		12	Change "motor" to "rotor."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
12	Exercises (405)-8	1	After "Drive shaft" insert ",,".
	Exercises (405)-8	3	Change "cylinder block" to "housing."
22	Exercises (407)-4		Move "Using the schematic in figure 2-4, determine in which position you should place the valves to operate or isolate specified systems." to the first part of Exercise (407)-5.
24R		34	Between "doubt" and "the" insert "of."
32R		7 from bottom	Between "compensator" and "empty" insert "is."
39R		32 from bottom	Change "for" to "or."
54	Exercises (425)-1.a		Under "Column B Functions" change "320°" to "360°."
55L		25-26 from bottom	Duplication - delete "about one-third . . . power contact arm."
74	Exercises (437)-7		Change "quality" to "quantity."
83	Exercises (442)-2	1	After "manual" delete "hydraulic."
93	Exercises (447)-4	3	Change "pressures" to "loads."
93L		8 from bottom	Change "They" to "The."
103L		14 from bottom	After "not" insert "be."
105	Exercises (453)-1		Under Column A, item 4 is duplicated. Delete one of them.
107R		28 from bottom	Between "understanding" and "the" insert "of."
112L		10	After "maximum" insert "turn."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
112L		Between 10 & 11	Insert "The return accumulator (compensator) (D) is located in the system return line. It maintains a small amount of pressure in the steering actuators when the control valve is in neutral. Such a."
118R		27 from bottom	Change "build" to "built."
121L		10	Delete "is."
121L		11	Delete "it."
129R		14 from bottom	Change "valves" to "values."
131	Answer 406-8		After the answer number, insert "F."
135	Answer 459-7		Delete "The slave metering valve then meters main system pressure to the brake assembly."
135	Answer 460-3		Move answer in line with other answers.

CHANGES FOR THE TEXT: VOLUME 4

7L		8	Change "pressur" to "pressure."
12L		3 from bottom	Change "hav" to "have."
19R		28	Change "ight" to "light."
21R		17-19 from bottom	Delete "As each . . . shock strut."
27R		8 from bottom	Change "negatie" to "negative."
31L		17	Change "mor" to "more."
34R		24	Change "view A" to "view B."
34R		28	Change "view B" to "view A."

PAGE-COL	SUBJECT	LINE(S)	CORRECTION
35	Exercises (620)-4		Change "extortion" to "extension."
44L		1	Change "yaw" to "pitch" and insert "The motion about the vertical axis is called "yaw."
51R		7	Change "level" to "lever."
57	Exercises (633)-5		After "flow" delete the "?" and insert "when the flap selector switch is placed to the DOWN position?"
71R		3 from bottom	Between "valve" and "Located" insert "see foldout 11."
72R		23	Change "and" to "of."
76L		6-7 from bottom	Change "Determien" to "Determine."
79	Answer 604-2.a		Duplication - delete "pressure test gage."
80	Answer 612-3		Delete "and in the DOWN position."
80	Answer 615-1		Change "utility" to "Auxiliary."
80	Answer 615-9		After the answer, insert "(anti-skid valve)."
81	Answer 626-6		Answer 6 is missing. Insert "6. Shape of airfoil."
81	Answer 627-1		Change "lateral" to "pitch."
82	Answer 633-3		Change "shuttle" to "restrictor."

REPLACEMENT PAGES: Insert the following replacement pages: 25 and 26.

4. What causes the hook to extend when the hook is released from the uplock?
5. What unit prevents hydraulic pressure surges from affecting arresting gear retraction?
6. How is the spring loaded uplock mechanism released?
7. What controls the speed at which the arresting hook extends?
8. How long will it take before the selector valve is deenergized and relieves hydraulic pressure from the bottom of the vertical damper cylinder?

2-2. Nosewheel Steering

The use of nosewheel steering and damping systems makes it possible to steer aircraft in confined areas without creating the usual disturbance or problems that stem from accelerating the engines or applying the brakes. The resultant longer life of engines and brake linings on aircraft using nose steering and damping systems justifies their use.

Pressure from the aircraft hydraulic system is used to turn the nosewheel either left or right, depending on the pilot's selection. Also, the type of aircraft determines if the system is operated manually (mechanically) or electrically. In this section we talk about the construction and operation of these two types of nosewheel steering systems.

613. Specify the constructional/operational features of a cable-operated nosewheel steering system.

Cable- (Mechanically) Operated Nosewheel Steering System. Most larger type aircraft use a cable-operated steering system as pictured in figure 2-6. The steering wheel is cable-connected to a steering collar on the strut. Notice that the rocker arm has pulleys for the cable and is able to pivot and position a metering valve in the steering control valve. The steering actuators can rotate the nose strut steering collar a specific amount, depending on the aircraft involved. Let's see what happens when the steering wheel is

turned. At the beginning of a right turn, the cables with the black arrows become tight, and the cables with the white arrows become slack. This action changes the tension on the metering valve rocker arm, causing it to pivot. When the metering valve rocker arm pivots, the metering valve mechanism is positioned to send pressure to the steering actuators to rotate the nose-wheel strut assembly. The steering cylinders are double-acting hydraulic actuators. The cylinder barrels are designed to remain stationary, but the piston rods, attached to the steering collar, are movable. The steering collar is attached to the upper torque link of the strut. The lower torque link is attached to the strut piston. Both torque links are jointed together to provide a mechanical linkage between the steering collar and the lower portion of the strut. Normally, whenever the aircraft is to be towed, the upper and lower torque links can be separated. If the torque links are not separated during towing, the fluid in the steering cylinders would have to transfer from one cylinder to the other. With the torque links disconnected, just the lower portion of the aircraft strut rotates. As the steering cylinders move, notice that the steering collar also moves in a direction that tends to equalize the tension on the cables. This is commonly called a followup action and allows the metering valve to return to center, which stops fluid pressure to the steering actuators once the desired amount of travel has been acquired. The return fluid from the cylinders must flow through the compensator of the steering metering valve. The compensator keeps a certain amount of back pressure in the lines for shimmy damper action.

Exercises (613):

1. If the control wheel is rotated clockwise, which direction will the gear move?
2. When towing the aircraft, why should the torque links be disconnected?
3. What repositions the selector valve to neutral when the gear reaches a desired position?
4. What parts of the steering cylinder are stationary and what parts are movable?
5. What portion of the strut is attached to the strut piston?

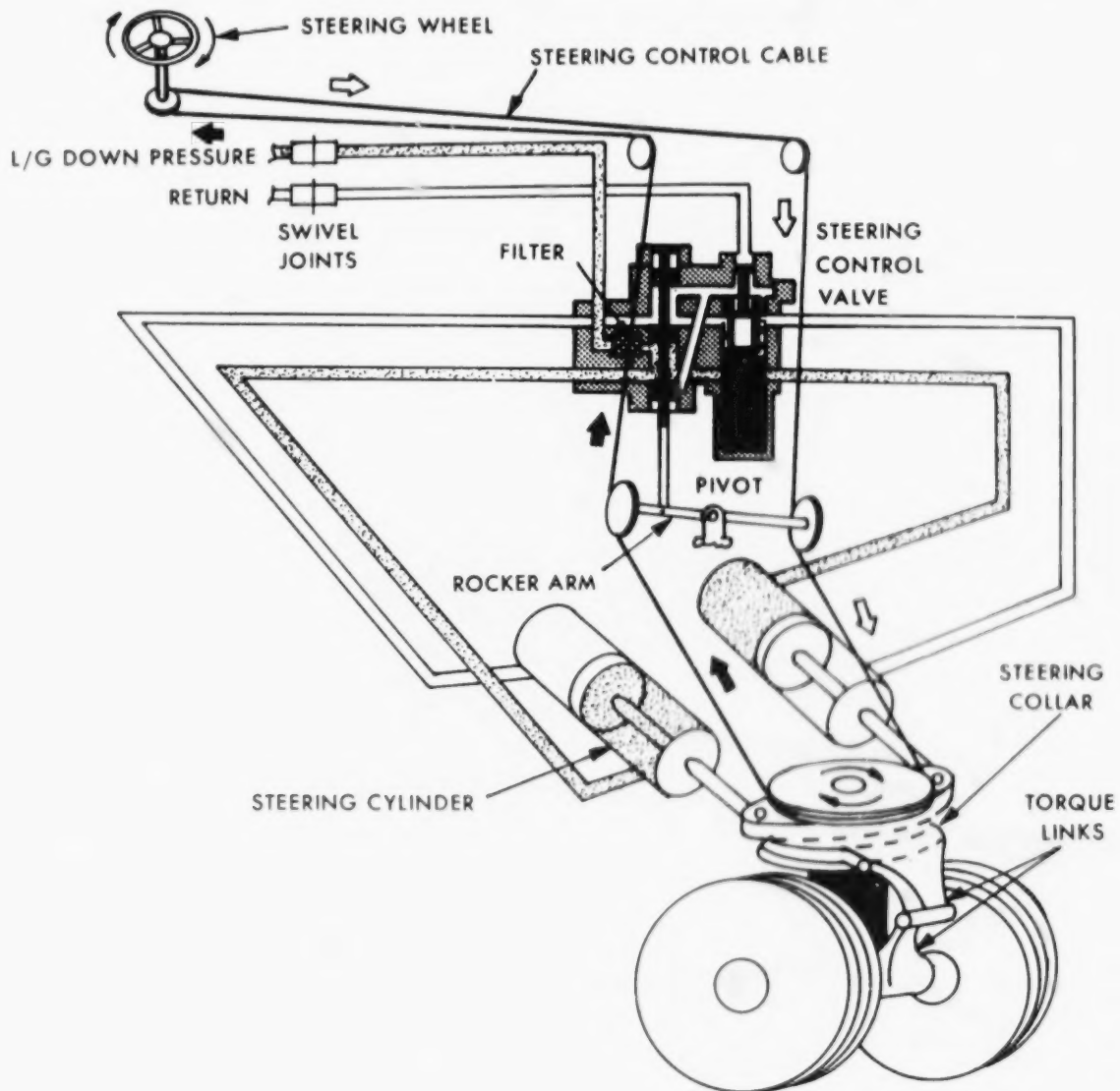


Figure 2-6. Cable operated nose wheel steering.

6. What portion of the steering system is able to pivot and position a metering valve in the steering control valve?

614. Cite the function of the components and specify the operational characteristics of an electrically operated nosewheel steering system.

Electrical Nosewheel Steering System Construction.
As a mechanic responsible for maintaining the nose

gear steering system, you must become familiar with each component. Each electrically operated nosewheel steering system varies in its construction, but you should be able to apply the principles presented here to each system you encounter. Let's begin our discussion with the function of the nose gear steering components. Refer to foldout 6 (found in a separate inclosure) as we talk about the components and system operation.

The command potentiometer is attached mechanically to the rudder pedals. When the rudder pedals are in any position other than NEUTRAL, a signal is produced that is fed into the differential amplifier

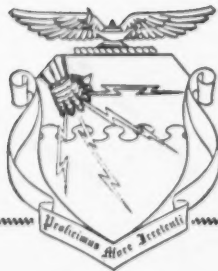
42354 01 7803

CDC 42354

AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC
(AFSC 42354)

Volume 1

Shop Administration



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Air University

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND
IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS IS the first volume of the new *Aircraft Pseudraulic Systems Mechanic* CDC, which is written for upgrading to the 5 level exclusively. This CDC covers all the knowledge elements listed in the Speciality Training Standard (STS) that reflect upgrading between the 3 and 5 levels. Information required for advancement from the 5 to 7 level is not included.

The first volume of this four-volume course presents general information on shop administration. It presents information on subjects such as career progression, training, security, publications, supply, the maintenance data collection system, maintenance management and supervision and safety. The second volume will cover fundamentals of pseudraulics, tools, and various types of equipment. The third volume will go into the various components in the hydraulic and pneumatic systems. The fourth and final volume will cover the various hydraulic pneumatic systems on an aircraft, such as landing gear, flight controls, power systems, and last but not least the inflight refueling system.

Foldout 1 is printed and bound at the back of this volume.

In this course, you will find the singular pronoun he, his, or him used in its generic sense, not its masculine sense. The noun to which it refers is "person."

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOXC, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of October 1977.

Contents

		<i>Page</i>
	<i>Preface</i>	iii
<i>Chapter</i>		
1	Career Progression and Training	1
2	Security	23
3	Air Force Publications	41
4	Supply	70
5	Data Reporting Systems and Forms	92
6	Maintenance Management and Supervision.....	116
7	Safety	140
	<i>Answers For Exercises</i>	161

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Career Progression and Training

MODERN technology, research, and development enable today's aircraft to fly at altitudes and speeds never before attained. New ideas have brought about design changes and improved system effectiveness. Systems are becoming more complex and employ some of the most up-to-date equipment in the world.

As the Air Force's fleet of modern aircraft grows, so does its need for skilled mechanics. Special skills are required to maintain these new systems. To obtain these skills the Air Force conducts a continuing training program. Each specialist is trained and given the opportunity to increase his knowledge and skills, thereby, advancing in his particular field.

This advancement (progression) has a twofold impact. First, the Air Force is assured of having the necessary skills to accomplish its mission. Second, training makes the trainee's job easier and could possibly lead to an increase in rank, pay, and responsibility. "Interested?"

1-1. The Air Force Career Program

The Air Force requires personnel with many skills. Therefore, the career program was devised to fill this need. Utilizing the career program, the Air Force determines what work needs to be done and what personnel are required to do the work. At this time, the career program is divided into approximately 50 career fields. Each career field is responsible for its portion of the total workload of the Air Force. Among them is the 42 career field in which you are assigned. The career field program, then, is the master plan for using people to accomplish the Air Force mission.

A very important factor for advancement in the Air Force is knowing your career ladder progression. In the following objectives we will discuss terminology used to describe career fields,

the organization of the Aircraft Systems Maintenance Career Field and career progression.

001. Give the specialties in the Accessories Systems subdivision and relate the career field terms to its definition.

Our concerns here are the Aircraft Systems Maintenance Career Field, aircraft accessory systems, and terms and definitions basic to the field.

Aircraft Systems Maintenance Career Field. Under the Air Force career program, all personnel must be classified—i.e., placed into related groups. As an example, it would not be logical to place a cook in the same career field as yourself. The Aircraft Systems Maintenance Career Field (42) in which you are assigned does exactly as its name implies; the personnel in this career field work on aircraft systems. Hence, a career field is a grouping of related AFSs involving basically similar knowledges and skills. The 42 career field is divided into two subdivisions, which are the Aircraft Engines and Aircraft Accessory Systems (see fig. 1-1).

Aircraft Accessory Systems. The Aircraft Accessory Systems subdivision is divided into six specialties: (1) Electrical, (2) Environmental, (3) Egress, (4) Aircraft Fuel, (5) Pneumatic, and (60) Aerospace Ground Equipment. Figure 1-2 is a Career Field Chart showing the relationship of AFSs grouped into a career field subdivision and the progression steps in each career ladder. Naturally, you are most concerned with the Pneumatic Systems Specialty; so study the Career Field Chart for a brief moment, paying particular attention to the Pneumatic ladder and progression steps.

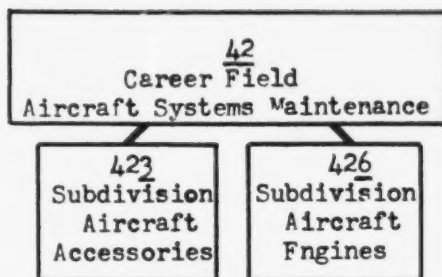


Figure 1-1. Career field.

Terms and Definitions. Before we go further into our discussion of the career program, let's take a look at some common terms and definitions you will find throughout the discussion. These are:

1. **Career Field Ladder.** This is a vertical (up or down) arrangement of an AFS. These ladders indicate both skill level and progression from entry into the Air Force right to the top of the ladder.

2. **Air Force Specialty (AFS).** The AFS constitutes a grouping of positions which require common qualifications. An AFS is identified by a title and a code. (For example, 'Aircraft Pneudraulic Systems Mechanic' is the title and "42354" is the code.)

3. **Air Force Specialty Code (AFSC).** Each AFSC is a combination of digits (numbers) used to identify an Air Force Specialty. Some AFSCs also include letters to indicate shredsouts or further breakdowns of a specialty. (As an example, a T placed before an AFSC (T42354) would indicate instructor qualified). Each number or group of numbers in an AFSC has a definite meaning. Let's see what these numbers mean, using AFSC 42354 as an example. (See fig. 1-3.)

a. The first two digits identify the career field. In this case, the 42 denotes the Aircraft Systems Maintenance Career Field.

b. The third digit (3) identifies the career field subdivision of the larger Aircraft Systems Maintenance Career Field.

c. The fourth digit (5) identifies the skill level. The Air Force uses skill levels 3, 5, 7, 9. Thus, AFSC 42354 refers to an aircraft pneudraulic systems mechanic (5 level). An X placed in the fourth digit position does not indicate any particular skill level in the career field but is used only as a generality when referring to the AFSCs.

d. The fifth digit (4) identifies the specific Air Force Specialty, which is Pneudraulic.

4. **Awarded Air Force Specialty Code (awarded AFSC).** This is the AFS authorized following certification of your ability to perform the duties of the AFS at a specified skill level.

5. **Primary Air Force Specialty Code (primary AFSC or PAFSC).** This is the awarded AFS in

which you are most highly qualified to perform duty.

6. **Additional Air Force Specialty Code (additional AFSC).** This is an awarded AFS other than the PAFSC.

7. **Duty Air Force Specialty Code (duty AFSC or DAFSC).** This is the AFS of the authorized manning document position to which you are officially assigned. A manning document tells the number of people that will be in each unit, the types of skill needed, and the skill level authorized for each position listed. Occasionally, because of manpower shortages, an airman is actually assigned to a manning document position that has a higher or lower skill level than the one he actually possesses.

8. **Control Air Force Specialty Code (control AFSC or CAFSC).** This code governs airman assignments and assists in the identification and control of training requirements. Your CAFSC identifies you highest usable skill in terms of the total Air Force requirement. The CAFSC, thus, is a management tool which the Air Force uses to assign airmen to the jobs where they are most needed, or to train them to fill these jobs at a later date.

Exercises (001):

1. List the specialties in the Accessory Systems subdivision.

2. Match each correct definition in column B with its related term in column A. NOTE: Each item in 1. List the specialties in the Accessory Systems subdivision.

2. Match each correct definition in column B with its related term in column A. NOTE: Each item in column B may be used once or not at all.

Column A Terms	Column B Definitions
— a. Career Field.	1. The awarded AFS in which you are most highly qualified to perform duty.
— b. Primary Air Force Specialty Code.	2. The listing within a progressively more detailed grouping of those skill, knowledge, and administrative elements required for the acquisition of purely mandatory abilities and attitudes necessary to adequate job performance.
— c. Air Force Specialty Code.	3. A combination of digits and letters used to identify an Air Force Specialty.
— d. Career Field Ladder.	

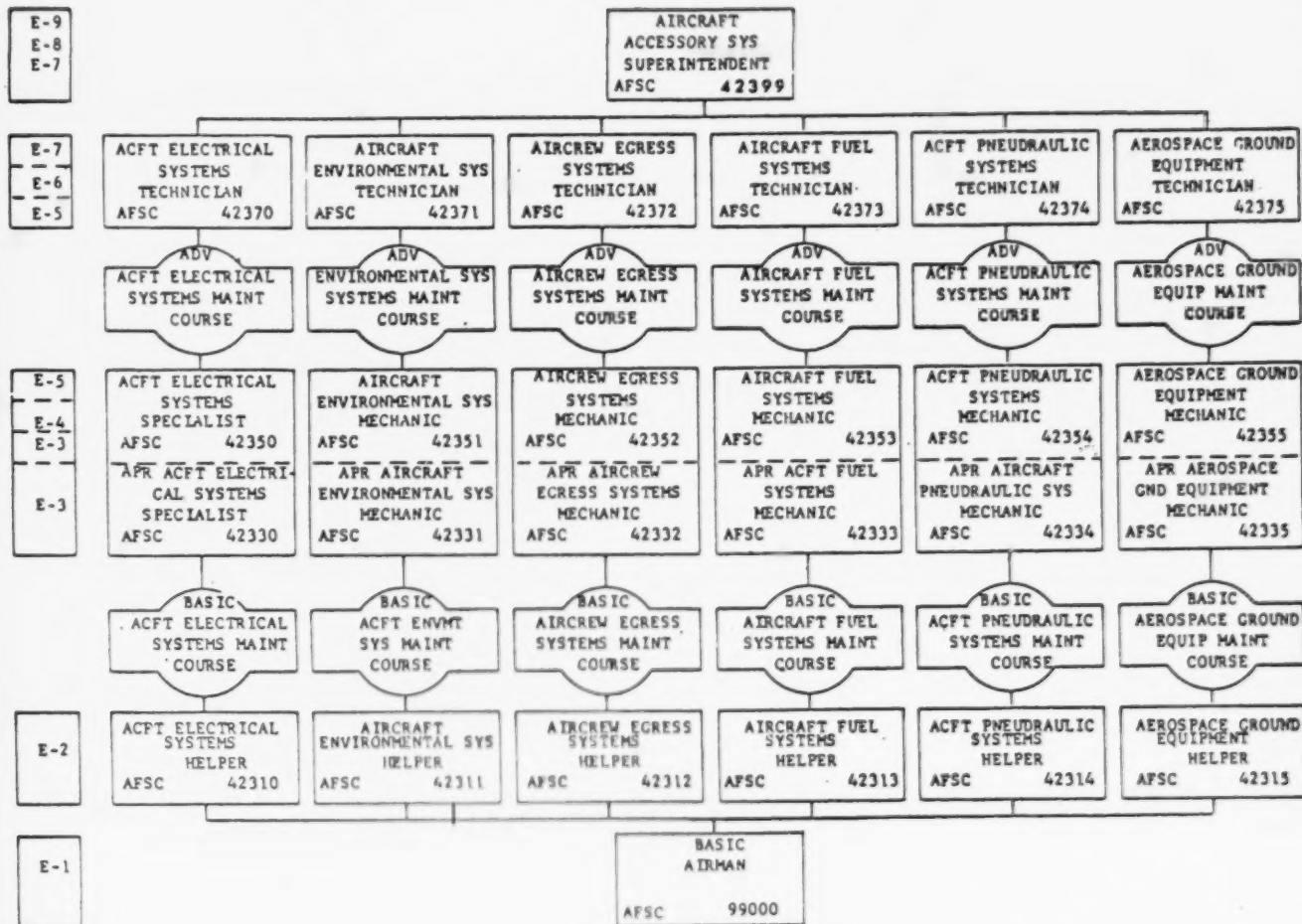


Figure 1-2. Career Field Chart.

4. A vertical arrangement of AFSs within a career field subdivision to indicate both skill level and progression.
5. A grouping of related AFSs involving basically similar knowledges and skills.
6. A combination of digits (numbers) used to identify an Air Force Specialty.

002. Describe briefly the purpose of each section of the specialty description of the aircraft pneudraulic systems mechanic.

Specialty Description. The specialty descriptions appearing in AFR 39-1, *Airman Classification Regulation*, describes the duties, responsibilities, and special qualifications needed to perform in a given AFS. Figure 1-4 shows the specialty descriptions of the 5 skill level. Refer to the specialty description while we talk briefly about its contents.

The specialty description is broken down into these four sections: (1) the Specialty Summary, (2) Duties and Responsibilities, (3) Specialty Qualifications, and (4) Specialty Data.

Specialty Summary. This is a condensed form of all of the duties and responsibilities performed by the aircraft pneudraulic systems mechanic.

Duties and Responsibilities. It contains all of the tasks that are required to perform in this AFS. However, it does not tell how these tasks are performed. All training is directly associated with this section of the specialty description. As an example, you would not be required to remove and install an aircraft engine because it is not covered in this specialty description.

Specialty Qualifications. This section is broken down into knowledge, education, experience,

training, and other. They are all self-explanatory, except item (2) under "other." It says "A minimum aptitude level of Mechanical 40 or Electronic 40 is mandatory." You must have gotten at least a 40 in mechanical or electrical on your Airman Qualification Examination (AQE) in order to be accepted into this AFS.

Specialty Data. This gives the grade spread and also the types of jobs that are related to the aircraft pneudraulic mechanic.

This completes our review of an AFR 39-1 Specialty Description. Next we will look at the duties of each skill level.

Exercises 002:

1. What information is found in the Specialty Summary?
2. If you were told to remove and replace a propeller on an aircraft, would this be part of your duties as an aircraft pneudraulic mechanic? Explain briefly.
3. From looking at the specialty description, does an aircraft pneudraulic mechanic supervise personnel?
4. What is the purpose of the specialty description?
5. In what AFR would the specialty description for an aircraft pneudraulic mechanic be found?

42	CAREER FIELD	Aircraft Systems
3	CAREER FIELD SUBDIVISION (when combined with first two digits)	Aircraft Accessories Systems
5	SKILL LEVEL	Mechanic
4	SPECIFIC AFS (when combined with first four digits)	Pneudraulic

Figure 1-3. Air Force Specialty Code.

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AFM 39-1 Volume II(C26) Attachment 21 1 February 1977 Effective 30 April 1977

A21-23
AFSC 42354
Semiskilled AFSC 42334
Helper AFSC 42314

AIRMAN AIR FORCE SPECIALTY

* AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC

1. SPECIALTY SUMMARY

Inspects, troubleshoots, installs, repairs, overhauls, and modifies aircraft pneumatic/hydraulic, in-flight refueling systems, and associated pneumatic/hydraulic aerospace ground equipment.

2. DUTIES AND RESPONSIBILITIES

a. *Performs preventive maintenance on aircraft, in-flight refueling systems; and ground support equipment pneumatic/hydraulic systems.* Accomplishes periodic and special inspections on pumps, accumulators, reservoirs, valves, cylinders, brakes, wheels, shock absorber struts, filters, shimmy dampers, control surface booster units, flying boom assembly and related equipment. Observes for air, inert gas or fluid leaks in reservoir, cracks and external damage, and security of mounting. Checks brakes for sponginess, cracked and chipped linings, clearance, warped discs, and accumulator air pressure. Checks components and subassemblies for operation, adjustment, pressures, internal leakage, external leaks under pressure, synchronization, and sequencing, using portable test stand for power supply. Removes, installs, and services aircraft pneumatic/hydraulic systems, in-flight refueling systems, and related ground equipment.

b. *Installs and repairs aircraft pneumatic/hydraulic and in-flight refueling components and ground equipment pneumatic/hydraulic components.* Disassembles, cleans, repairs, assembles, and tests pneumatic/hydraulic and in-flight refueling accessories. Removes covers, poppets, springs, cam seals, pistons, valves, and valve seats. Examines parts for wear, scratches, cracks, and damage. Inspects seals, gaskets, and hose for tears, nicks, and other damage. Inspects equipment removed from storage for condition and any obvious damage. Resurfaces valve seats and valves. Hones and polishes cylinders and pistons to remove scratches and to assure fit. Replaces bushings, bearings, and bearing sleeves. Reworks parts of systems and their components, including landing gear, wing flaps, cow flaps, carburetor air inlet doors, bomb doors, windshield wipers, shock struts, brakes, flying boom assembly, jacking equipment aerostands, and portable hydraulic test stands. Reconditions and tests pneumatic/hydraulic

units, and in-flight refueling units such as accumulators, actuating struts, selector valves, control valves, and relief valves. Adjusts, aligns, rigs, and calibrates pneumatic/hydraulic components, and flying boom components to insure maximum operating efficiency consistent with design characteristics. Troubleshoots aircraft pneumatic/hydraulic systems, in-flight refueling systems, and components of aircraft pneumatic/hydraulic, and in-flight refueling systems. Performs corrosion control.

c. *Inspects, tests, installs, repairs, overhauls, and modifies aircraft in-flight refueling electrical systems.* Troubleshoots malfunctions of components, such as signal amplifiers, nozzles, instrument gauges, and flying booms. Replaces defective parts with serviceable items. Adjusts and repairs electrical devices such as elevation, telescope, and azimuth control assemblies, and performs operational tests of aircraft in-flight refueling electrical accessories. Conducts detailed tests of in-flight refueling electrical systems using ohmmeter, voltmeter, and electrical test equipment. Isolates malfunctions by visual inspections and electrical checks, and observes instrument indications. Adjusts, aligns, and calibrates aircraft in-flight refueling electrical systems to insure maximum operational efficiency consistent with design characteristics, using wiring diagrams and technical publications.

d. *Supervises aircraft pneudraulic systems maintenance personnel.* Assigns preventive maintenance and repair tasks to subordinates and observes performance to insure compliance with local procedures and applicable technical publications. Instructs subordinates in techniques of installation, repair, and maintenance of aircraft pneumatic/hydraulic systems, in-flight refueling systems, and ground equipment pneumatic/hydraulic systems.

3. SPECIALTY QUALIFICATIONS

a. *Knowledge.* Knowledge of electrical and mechanical principles as applied to aircraft, in-flight refueling, and associated ground equipment pneumatic/hydraulic systems; and use and interpretation of blueprints, wiring diagrams, and technical publications is mandatory. Possession of mandatory knowledge will be determined according to AFR 35-1.

b. *Education.* Completion of high school with courses in hydraulics or general science is desirable.

c. *Experience.* Experience in functions such as

installation, modification, or repair of aircraft or associated ground equipment pneumatic, hydraulic and electrical systems and components is mandatory.

d. *Training.* Completion of a basic aircraft pneudraulic systems maintenance course is desirable.

e. *Other:*

(1) Normal color vision as defined in AFR 160-43 is mandatory.

(2) A minimum aptitude level of Mechanical 40 or Electronic 40 is mandatory.

4. SPECIALTY DATA

a. *Grade Spread:*

Airman first-class through
staff sergeant 42354
Airman first-class 42334

b. *Related D.O.T. Jobs:*

Aircraft Mechanic,

Heat and Vent 801.381
Aircraft Mechanic, Plumbing and
Hydraulic 862.381
Fuel System Maintenance
Man 630.781

c. *Related DOD Occupational Subgroup:* 602

Figure 1-4. Specialty description (AFM 39-1).

003. Given specific information on skill levels, associate a series of duties and responsibilities with their proper 3, 5, 7, and 9 skill levels.

Job Titles. The job titles of your Air Force Specialty and the related specialty codes are as follows:

- Apprentice Aircraft Pneudraulic Systems Mechanic—42334.
- Aircraft Pneudraulic Systems Mechanic—42354.
- Aircraft Pneudraulic Systems Technician—42374.
- Aircraft Accessory Systems Superintendent—42399.

Let's begin by discussing the 3 skill level.

Three level. The duties and responsibilities of the 3 skill level are varied, yet they are limited for the protection of the individual and the maintenance activity to which he is assigned. As a newly assigned 3 skill level, you will be devoting many hours in study toward advancement within the career ladder and will be closely supervised during training on the job. Your responsibilities will be limited but will be increased gradually as you gain experience. As a 3 skill level, you will be required to perform most maintenance tasks and much of your work will be under the supervision of your OJT trainer.

Five level. The duties of the 5-level mechanic are much the same as those of a 3 skill level with a few exceptions. The big difference lies in the amount of supervision required. A 5-skill-level repairman is required to be competent in most areas, although there are a few areas that require only minimum proficiency. These levels of competency are determined by the coding in the Specialty Training Standard (STS) or Job Proficiency Guide (JPG). STSs and JPGs are discussed in more detail later in this chapter. The 5-skill-level mechanic can also function, in many instances, as an OJT trainer for 3-skill-level trainees. Because he performs in this position, the capability to supervise men is also a requirement for obtaining the 5 skill level.

Seven skill Level. A 7-skill-level technician is required to analyze problem areas concerning a job and to come up with a good solution. Although the 7 skill level must have the ability to do 5-skill-level work, he must also plan workloads and schedule work assignments, improve work methods, establish procedures, prepare and analyze reports, determine personnel requirements, develop organizational structures, establish work standards and job priorities, and coordinate and determine individual and group needs for training. It should be obvious that the 7-skill-level supervisor is a man who must anticipate the needs of his section and take the necessary steps to provide for them.

Nine skill Level. A 9-skill-level superintendent's primary duties are concerned with supervision, planning and organizing maintenance activities, establishing training programs, and other shop management type activities.

Exercise (003):

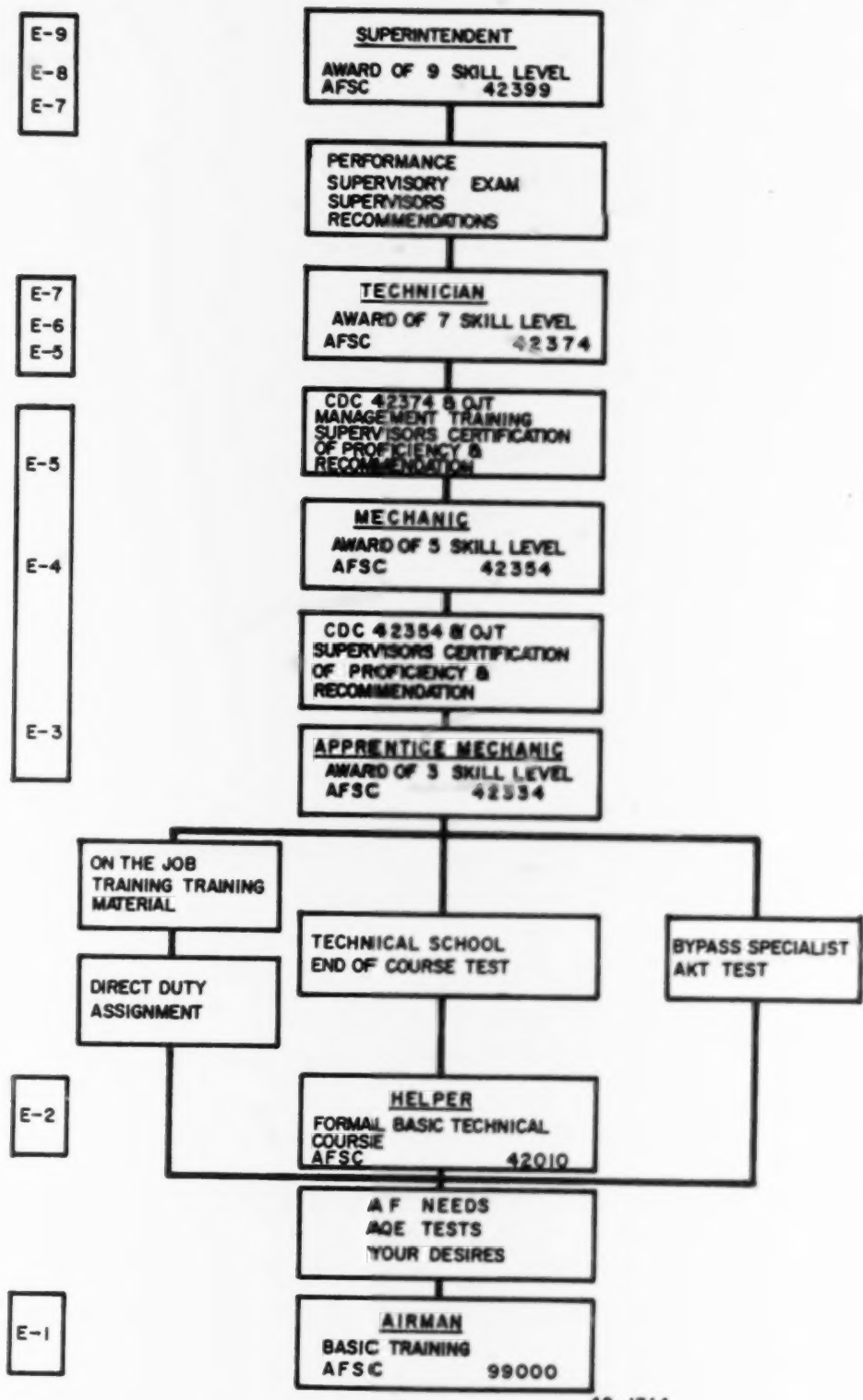
1. Match each duty description found in column B with its related skill level listed in column A. NOTE: Each column B item may be used once or not at all.

Column A Skill Levels	Column B Duty Descriptions
— a. 3 skill level.	1. Determines individual and group training needs.
— b. 5 skill level.	2. Requires close supervision at all times.
— c. 7 skill level.	3. Plans workloads and schedules work assignments.
— d. 9 skill level.	4. Requires only limited supervision.
	5. Manages shop activities.

004. Analyze career progression in the 42374 field by specifying the routes taken from basic recruit to superintendent and the procedures in obtaining each skill level.

Career Progression. Your career progression in your chosen field, including promotion, is directly related to your efforts to improve and maintain qualification in your AFSC. Career progression involves both job proficiency and general background knowledge on military and career area functions. The latter you will learn by self-study, using Career Development Courses (CDCs). Satisfactory completion of the CDC is necessary before you are eligible for upgrading. The steps for career progression are from the basic 3 skill level to the 5 skill level, from the 5 skill level to the 7 skill level, and then from the 7 skill level to the 9 skill level.

Basic recruit to 3 skill level. Do you recall when you entered the Air Force? You were assigned code 99000. This meant that you were a basic recruit not yet assigned to a career field. At this point, you were given an Airman Qualification Examination (AQE). The AQE tested you in four knowledge areas. Those areas were: mechanical, administration, general, and electronics. On the basis of your scores, and interviews with personnel placement officials, you were placed in a career field. Your background an Air Force needs were also considered in assigning you. When you completed basic military training, three avenues were available to you for progression to the 3 skill level. (See fig. 1-5.) One avenue was through



42-1314

Figure 1-5. Skill progress.

satisfactory completion of a formal technical training course. The AFSC you were assigned upon entry into Technical School was 42010 (Aircraft Systems Maintenance Helper). After completing the course you were awarded AFSC 42334 (Apprentice Aircraft Pneudraulic Systems Mechanic). The second possible avenue was a bypass specialist. If you were qualified for a specialty by virtue of prior civilian or military occupational experience and schooling, you could have been designated as a "bypass specialist" and assigned without having to attend a formal school for technical training. However, you must still qualify on the appropriate specialty knowledge test, which is known as the AKT (Apprentice Knowledge Test), before being awarded a 3 skill level.

The third avenue is not so cut and dried. It is a direct duty assignment (DDA). Here an individual's success is dependent upon his ability at self-study and his job proficiency.

Direct duty assignees are in the dual-channel training concept. Approved training materials, such as technical orders (TOs), CDCs, and manuals, are used by the trainee to help prepare himself for the specialty knowledge test (SKT). This is his knowledge training. Meanwhile, his performance on the job is supervised and evaluated. He is given instruction and assistance whenever needed to help him meet prescribed standards. This part of his training is his proficiency training, and must be certified by his supervisor. The combination of the knowledge and the proficiency training is considered to be dual-channel training.

3 skill level to the 5 skill level. Progression from the 3 skill level to the 5 skill level is the same for everyone within the same AFS. To qualify for the 5 skill level, you must already possess a 3 skill level and have certain knowledge and experience. To acquire the knowledge necessary to progress from the 3 to 5 skill level, you must satisfactorily complete the 42354 Career Development Course (CDC). When you have completed all volumes of this course, you will be given the course examination (CE). After passing the CE, one of the big hurdles is out of the way toward becoming a 5-skill-level mechanic. However, there is more to it than passing the CE. In addition, you must demonstrate that you can do the job of a 5-skill-level mechanic. If you perform satisfactory on the job (normally 6 months), and are recommended by your supervisor, you can be awarded the 5 skill level and the title of mechanic.

Why is it important for you to be upgraded in your AFSC? Probably the most important reason to you is that your eligibility for promotion is partially based on your AFSC. You must be a 5 skill level to be promoted from sergeant (E-4) to staff sergeant (E-5).

5 skill level to the 7 skill level. Award of the 7 skill level is restricted to 5-skill-level airmen in

grade E-5 (SSgt) and above by AFR 35-1. You must satisfactorily complete CDC 42374 and the course examination. The completion of management training is a prerequisite to upgrading to the 7 skill level of any AFS. Any of the following will satisfy this requirement:

- a. Extension course number 7B (non-commissioned officer leadership course).
- b. An accredited NCO Academy leadership course as defined in AFR 50-39.
- c. A base level accredited management course for AF supervisors (management 1).

You must also perform in a 7-skill-level capacity for a period of 1 year, and be recommended by the supervisor. After completion of these requirements you can be awarded AFSC 42374 and the title of technician. The 7 skill level is necessary for promotion to technical sergeant (E-6) and master sergeant (E-7).

7 skill level to the 9 skill level. Award of the 9 skill level is restricted to airmen in grade E-7 (MSgt) and above. The aircraft accessories superintendent is at the top of the career progression ladder. To obtain this position he must progress through any one of the six specialties in the Aircraft System Accessories Career Field subdivision, and familiarize himself with the other specialties. No CDC is required when progressing to the 9 skill level. However, the individual must pass a 9 skill level supervisor's examination and be recommended by his supervisor. A 9 skill level is referred to as a superintendent, and personnel on this level can be promoted as high as chief master sergeant (E-9).

Exercises (004):

1. What is a "bypass specialist?"
2. Clarify the three separate routes a specialist might take in obtaining a 3 skill level.
3. Which of the items from the following list are requirements for progression from the 3 to the 5 skill level?
 - a. Complete a formal basic course.
 - b. Have at least 6 months experience doing the job of a 5 skill level.
 - c. Successfully complete the CDC.
 - d. Be recommended by your supervisor.
 - e. Have 6 months time in grade.
 - f. Have 6 months experience doing the job of a 3 skill level.

4. What skill level is required to be eligible for promotion to staff sergeant?
5. List the requirements necessary to progress from the 5 to the 7 skill level.
6. Cite the requirements necessary to progress from the 7 to 9 skill level.

005. Cite and explain briefly the factors which are considered in the Weighted Airman Promotion System.

Career progression from one grade to another is a significant part of your Air Force life. The present system provides personnel in each AFSC equal opportunity for promotion. Promotions from airman (E-2) to sergeant (E-4) are recommended by the commander when you are eligible and qualified.

Weighted Airman Promotion System (WAPS). The WAPS selects airmen for promotion to the grades of staff sergeant (E-5) through master sergeant (E-7). Basically, WAPS selects airmen for promotion on the basis of the total score of certain weighted factors.

The weighted factor selection system is as follows:

1. **Specialty Knowledge Test (SKT).** The SKT measures the knowledge concerning your Air Force Specialty (AFS). This test is administered annually, with a possible score of 100.
2. **Promotion Fitness Examination (PFE).** The PFE measures your knowledge of military subjects and management practices at a specific grade level. The PFE is normally administered at the same testing session as the SKT, with a possible score of 100.
3. **Time in Service (TIS).** TIS is computed by multiplying total years of active Federal military service by two; the maximum points for 20 years of active service is 40 points, less than 6 months count as one point, and 6 months or more as two points.
4. **Time in Grade (TIG).** TIG is figured at the rate of one-half point per full month in grade. Over 15 days of a month counts as one whole month. The maximum is 60 points for 120 months in grade.
5. **Decorations.** Decorations are assigned specific points according to their order of precedence. They range from one point for the Purple Heart to 15 points for the Congressional Medal of Honor. The same points will be given for repeat awards, or for equivalent awards earned in other military services

of the United States. A total of 25 points is maximum.

6. **Airman Performance Report (APR).** The APR is used as a measure of your past job performances. It reflects the sum total of your capabilities as demonstrated in your daily actions. It serves as an indication of your expected duty performance in future assignments within your career field. APRs are computed by taking an average of the overall ratings of the last 5 years of APRs and multiplying the average by 15; maximum points are 135. The APR score counts for more than one-fourth of the total WAPS score possible.

One of the main features of the WAPS is its visibility—you'll know exactly what you're being judged on, in comparison with others of the same grade and Air Force Specialty. You can see the importance of each promotion factor and its weight. You can even figure your own score on the known factors. If you are not selected for promotion, you will receive a written notice showing the scores you obtained on each factor, your total point score, and the total score for promotion of the last airman promoted during that specific promotion cycle in your AFSC. This visibility feature will show you where you might improve your promotion potential.

Improvement of your technical and educational level is a continuous process. Throughout your career you will be striving to improve your own competence, as well as the overall competence of your shop. As each man does his best at his individual job, the entire Air Force maintenance system will become more efficient and more effective.

Exercises (005):

1. What are the six factors considered in the WAPS?
2. What does the specialty knowledge test measure?
3. Which WAPS factor measure your knowledge of military subjects and management practices at a specific grade level?
4. How is time in service computed for the WAPS?

5. How many points will you receive under the WAPS for 3 years 4 months time in grade?
6. Which single weighted airman promotion factor accounts for more than one-fourth of the total WAPS score possible?

1-2. Training

You already know a great deal about on-the-job training because you have been a trainee for some time now. You have completed the 3-skill-level requirements of your specialty, and are now training for the 5 skill level. The information you gain in this section should help you to better understand the reason for your training. Also, it should aid you in your transition from "trainee" to the "trainer" you will soon be. Areas we will discuss are selecting and recommending personnel for training, planning and conducting OJT, and maintaining training records.

006. Specify selected factors used to indicate a training requirement exists for training.

Determining Training Needs. When new personnel are assigned, they must be evaluated to identify their technical qualifications, currency of training, and additional training requirements. Additional evaluations may be required when an individual changes job assignments, new equipment is programmed, or assigned equipment is modified.

If every trainee had the same degree of skill and the same qualifications, determining the training needs would be simple. However, no two airmen have exactly the same skill, ability, or attitude; and the job of finding out just what each one needs to learn in order to perform better is somewhat complex.

We cannot simplify the process by giving everyone the same training. This would be very costly, since many would receive unnecessary training, the trainer would waste valuable time needed for other duties, and the time of the trainee would also be wasted in training he doesn't need. What is more boring than going through a training program a second or third time? Finally, not all trainees have the same ability to learn. The problem facing you is to find out the needs of each individual so that your training program can be patterned to meet those individual needs.

The problem has two parts. The first part is determining what specific things the individual must do to accomplish the work completely and effectively. The second part of the problem is determining what the individual is capable of doing.

These two parts combine in the solution of the problem. The difference between what the trainee can do and what must be done represents his training needs.

To solve the first part of the problem, you must know what duties are involved in your mission. Explore each operation and examine the job qualification requirements. You can get information on work to be done from the specialty description, Specialty Training Standard (STS), and performance requirements.

To solve the second part of the problem, many ways are used to find out how much the trainee can already do. For example, usually records show his background, training, and experience. You can have the trainee show his skills by actual performance. Observing the trainee's methods and work habits on the job may reveal to you a need for additional training. Compare the trainee's performance with the performance requirements of the job. With the collection of all this data, you can plan your training program.

Exercises (006):

1. What is wrong with training every new person assigned to your shop on every job he is required to do?
2. Tell why it may be necessary to have a trainee perform a task.
3. Give one situation in which a person would be recommended for training.

007. Clarify OJT by defining it, relating it to the dual-channel concept, and using an example to exemplify a specific channel of OJT.

Here our topics are on-the-job (OJT) training and the dual-channel concept.

On-the-Job Training. On-the-job training is a planned training program designed to qualify airmen, through self-study and supervised instruction, to perform in a given Air Force Specialty (AFS). This is done while the trainee is actually working in a duty assignment of the AFS. OJT is conducted in the actual work situation by designated personnel within the unit who are working in support of the unit mission. Even though the responsibility for conducting on-the-job training is delegated to specific individuals within the unit, the overall OJT program is, and must be, of concern to every person assigned to the unit. The

nature and effectiveness of the training conducted in the unit today largely determine the quality of the work produced by the unit tomorrow.

Dual-Channel OJT Concept. The dual-channel concept is a systematic application of the "selfstudy" and "craftsman-apprentice" principles. Trainees acquire AFS knowledge by enrolling in studying Career Development Courses (CDCs). They acquire job proficiency while performing on the job under the supervision of a skilled worker.

Career development. Career Development Courses contain the fundamental knowledge required for on-the-job upgrade training. These courses are programmed and developed by the Air Training Command, which forwards the material to the Air University. The Extension Course Institute (ECI) of the Air University publishes and administers the Career Development Courses. ECI develops and publishes standard procedures for the administration of CDCs, information regarding the activation of CDCs, enrollment criteria, and special instructions. ECI also evaluates student progress in the courses and administers the course examination (CE). After its successful completion, the student is awarded a certificate.

Job proficiency. The entire OJT program hinges upon the learn-by-doing and self-study concepts. Job proficiency training is normally conducted within the unit to which the trainees are assigned for duty. The responsibility for conducting the job proficiency phase of OJT is a part of the job of each person who supervises the work of airmen.

Job proficiency training implies practical application. It places the trainee in an operational situation, where he is assigned certain specific tasks that are part of his duty. As the trainee acquires skill in the simpler tasks, he is assigned others that are progressively more complex. In this way, the trainee constantly broadens his skill until he can finally perform all elements of the job. Meanwhile, the organization benefits from the worker's productiveness while he is learning.

AFM 50-23, *On-the-Job Training*, has been prepared for the Air Force personnel who plan, administer, supervise, and conduct OJT programs. It contains detailed information and references that concern on-the-job training.

Exercises (007):

1. What is meant by on-the-job training?
2. Name the two channels in the dual-channel concept of OJT.

3. If a trainee is working on an aircraft, under supervision of his trainer, which channel of the OJT concept is he following?

4. What is the number and name of the manual controls the OJT program?

008. Given a list of OJT duties, select the person responsible for each.

Duties and Responsibilities for OJT. A sound OJT program is a necessary and integral part of the primary mission of every organization to which airmen are assigned. Every individual from commander to trainee must accept and discharge his OJT responsibilities. The program must have the full support of all concerned if it is to achieve its purpose. By making the OJT program successful, we realize the fullest potential of our most valuable resource—our assigned personnel. Duties and responsibilities for OJT are shared by the following individuals:

- OJT administrator.
- Immediate supervisor.
- OJT trainer.
- OJT trainee.

We will limit our discussion to those personnel with whom you will normally have direct contact concerning the completion of your OJT.

Squadron OJT administrator. Part of the OJT administrator's duties include indoctrination of the supervisor and the trainer in the concepts, scope, and objectives of OJT. He was likely one of the first people you met while processing in to your squadron. He reviewed your training records or prepared training records for you if you did not already have them. Once the determination was made that you should go on training for the 5 level, the OJT administrator ordered the CDC for you that you are now studying. He retained the volume review answer sheets and will administer the volume review exercise (VRE) after it is determined that you have completed all of the exercises for the objectives. He will mail your answer sheet to the Extension Course Institute (ECI) for grading, forward the results to your supervisor and insure that review training is provided as required. Any questions missed on a VRE requires a review of the material from which the question was taken.

Immediate supervisor. Ideally, the immediate supervisor is also the trainer. In cases where this is not practical due to the number of people on training, he will select qualified trainers within the section. The supervisor develops a Job Proficiency Guide (JPG) as the basic document for training,

based on the trainee's duty position. He also certifies job proficiency by initialing and dating opposite each task in the JPG as training for the task is completed. He provides the squadron OJT administrator with an estimated completion schedule of each volume of the CDC. Under normal circumstances, you are allowed 30 days to complete each volume. When your ECI grade cards (Form 9) are received, your supervisor will conduct review training on all items missed and document this training for future reference. All of this is shown in figure 1-6. When all training requirements are met, he will recommend you for upgrading. It is his responsibility to counsel you when problems exist. However, if you have a problem, don't wait for the supervisor to bring it up. Usually, the earlier a problem is identified and solved, the less serious it is for all who are involved.

OJT Trainer. The OJT trainer is responsible for conducting the actual OJT program as outlined by your supervisor. In some instances, he may even be your supervisor; but normally, he is the shift chief. You can expect that your OJT trainer will provide the technical know-how you must acquire. Remember, however, your trainer is not an individual assigned to full-time instructional duty. Rather, he is a skilled individual who is assigned to

a production job and who will have you, the trainee, as his assistant. Among his many OJT duties is the preparing of detailed task breakdowns for each airman, indicating the important steps involved in the task. He will teach theory and background information, when required, and instruct trainee's on actual equipment. He will motivate and evaluate the trainee to insure that each trainee becomes proficient in the performance of job tasks required to progress to the next higher skill level within his AFSC. This requires constant supervision of each step in the training program.

OJT trainee. Air Force policy places on you the responsibility for attaining and maintaining qualification in your Air Force Specialty (AFS). Facilities for self-improvement, such as off-duty education, ECI courses, technical training, and CDCs, are available or can be made available. Each individual is encouraged to use every opportunity to improve his technical qualifications and his professional and military knowledge. It is your responsibility, as a trainee, to understand your AFS description, the training requirements of your STS or JPG, and the contents of your training folder. You should accept and perform all training assignments as efficiently as you can. You must budget your time, both on and off duty, so that

REPORT OF COURSE EXAMINATION				as of 750506	
Name	ES E. W. HARDIN		SSAN	423344041 Course 54370	
Enrollment Date	750121		Number of Volumes in Course	06	
VRE/CE	DATE RECEIVED	SCORE	STUDY HOURS		
CE	750506	SATISFACTORY	045		
AREAS REQUIRING FURTHER STUDY.					
006 017 038 043 057 069					
COURSE COMPLETION CERTIFICATE BEING FORWARDED.					
REVIEW TRAINING ☒ NOT REQUIRED ☐ STARTED 18 May 75 DUE COMPLETION 28 May 75 COMPLETED 6 Jun 75					
ITEMS MISSING ABOVE		SUPERVISOR'S SIGNATURE		TRAINEE'S SIGNATURE	
ON ASSIGNMENT		Thomas B. Lingo, 1st Lt		Edward W. Hardin, 1st Lt	
					
ECI FORM 9 FEB 75 9 REPLACES ECI FORMS 19, 20, 21, 29, WHICH ARE OBSOLETE					

Figure 1-6. ECI Form 9 (grade card).

you can complete your CDC and local study assignments within the time limit. Maintain your training materials in good condition for future use. When you are reassigned, you are responsible for picking up CDC materials and answer sheets from the OJT administrator and delivering these materials intact to the OJT administrator at your new organization.

The foregoing is in no way intended to be an all inclusive list of duties and responsibilities for OJT. Complete, detailed information of this subject is found in AFM 50-23, Chapter 4.

Exercises (008):

Select the individual responsible for each of the following duties by placing a letter from column B in front of the number in column A. NOTE: Each item in column B may be used once or more than once.

Column A Listed Duties	Column B Responsible Person
___ 1. Selects OJT trainers.	a. Squadron OJT administrator.
___ 2. Orders CDCs for OJT trainees.	b. Immediate supervisor.
___ 3. Maintains training materials in good condition.	c. OJT trainer.
___ 4. Prepares JPG to indicate individual training needs.	d. OJT trainee.
___ 5. Administers VREs.	
___ 6. Conducts review training for items missed on VREs.	
___ 7. Teaches theory and background information.	
___ 8. Insures that the OJT administrator at the trainee's new assignment gets his training records.	
___ 9. Prepares detailed task breakdowns.	

009. Given selected information on training methods and techniques, associate specified methods and techniques with names characteristics.

This unit covers training methods, first, and training techniques, second.

Training Methods. Your trainer responsibilities are in addition to your other duties, because the OJT trainer function is not considered a full-time duty. Obviously, as an OJT trainer, you are neither required nor expected to become a professionally qualified educator. But you are expected to use certain training methods and techniques that are known to be effective. This requirement and responsibility are contained in the specialty description for AFSC 42354. It follows, then, that when you are selected as a trainer, you must learn to perform efficiently, using those methods that

made an OJT program effective. Job instruction generally involves four methods of imparting new knowledge or manual skills. (The order in which these methods are given is no particular recommendation of one method over another.)

Lecture. The lecture method is useful for informing trainees. Its effectiveness is increased, however, when it is combined with one or more of the other instructional methods. When the training objective is the development of new skills, such as operating a complicated new inspection unit, the lecture or "telling" method alone has limited value.

Discussion. Discussion is a valuable training method because it promotes a two-way exchange of ideas during group instruction, for example, to provide background information of common interest to the entire group. Questioning is very useful, when you are employing this method as, means to inform the trainee as well as to check his grasp of the instruction. To help the trainee think through the logical steps of a new task, phrase your questions so that they cannot be answered with a straight "Yes" or "No." Instead, use questions that begin with such words as "What," "Who," "Where," "When," "Why," and "How." Questioning and discussion can be used effectively with all other instructional methods.

Demonstration. Demonstration or "showing" is most valuable when the training objective is the development of new manual skills. It is particularly useful if you are presenting the various steps of a very long operation that must be performed without stopping. The trainee is taught a part of a job, with the trainer doing the rest. After learning one step of the total job, the trainee learns a second step, with the trainer again completing the operation. In this way, the trainee learns the whole job by small increments. The effectiveness of the demonstration method is increased when it is combined with the discussion method.

Performance. Performance is by far the most effective method in OJT. A trainee truly learns by doing under the careful eye of the trainer while performing in a productive capacity. An airman an OJT should immediately be given simple jobs to do. It is most practical to assign the airman to assist others who are producing. After an airman has received training on some particular task until he is able to do it with the desired proficiency, he should be rotated to another task. With a progressive rotation plan, the trainee grows in skill and knowledge until he can perform all of the tasks of the duty position.

Training Techniques. Supervisors must be sure that trainers use training techniques that achieve good result. The five steps discussed here have been used by many trainers to develop techniques of their own.

Prepare the training situation. Make sure that the tools and equipment you need are on hand and in

good working order. Also, see that the shop or room is available and is properly heated, lighted, and ventilated. In addition, have the training aids you plan to use available and in good working order.

Prepare the trainee to receive job instruction. Put the trainee at ease. Help him to build confidence. Your training efforts are likely to be in vain if the trainee is nervous or ill at ease. As an aid in trainee preparation, apply one of the principles of the developmental approach: go from the known to the unknown. To gain his interest, explain the job or operation at hand; then relate that job to the work of the whole unit. This approach will help him realize the importance of the job.

Another important consideration in trainee preparation is to demonstrate a job so that the trainee observes things from the proper position. That is, do not have him look at the job he will do backwards to or from an angle other than the one from which he will actually work.

Present the operation to the trainee. This means tell him, show him, illustrate for him, and question him. Then, when you think he understands, have him do the job. Apply the other principle of the developmental approach: go from the easy to the difficult. In this regard, make the key points clear. These make or break the operation; to a large extent, they determine the ultimate success or failure of the training. Use training aids when they help to put the point across, but do *not* use them just to fill in time. Consequently, before using any training aid, be sure that it applies directly to the subject and that it works. Of course, be patient. Remember that haste makes waste. So work for accuracy, first; speed, later. Also, repeat the job and explanation as necessary.

Try out performance. Do this by having the trainee perform the job under observation. Then have him do it again, this time asking him to explain what he is doing and why. The trainee must understand what he is doing.

Have the trainee explain the key points. Correct his errors, but do not correct him in such a way that he will make him feel that you are dissatisfied with his progress. Instead, continue to have the trainee perform and explain, perform and explain, etc. until you know that he knows.

Follow up. All this point, put the trainee on his own so that he can get the feel of doing the job by doing it all by himself. Tell him to whom he should go for help, and make sure that the designated person understands his responsibility. Check the trainee's work frequently—perhaps every few minutes at the start, then every few hours. Be on the lookout for incorrect or unnecessary moves, but do not make an issue of them. Expect a few mistakes. When there are none, congratulate the trainee for a job well done. Get him to look for key

points as he progresses. Taper off the coaching until he is able to work under normal supervision.

Exercises (009):

1. What method(s) uses the "show" principle?
2. If the instructor asks the student questions pertaining to the subject, what method is he using?
3. Which teaching method is most useful in presenting a new skill?
4. A trainee that learns by doing is using what method of instruction?
5. Helping the trainee build confidence in himself is a part of _____.
6. Illustrating the job for the trainee is included in _____.
7. Planning for the availability of the equipment and training aids you need is included in _____.
8. Letting the trainee do the job on his own and checking his work at frequent intervals constitutes _____.
9. Making sure that the trainee can explain what he is doing and why is a part of _____.

010. Given specific items for an On-the-Job Training Record, specify where each should be entered in that record.

On-the-Job Training Record. Upgrade training, lateral training, and retraining conducted on the job are intended to end in the award of an AFSC.

However, without some method for recording training at section level, individual units would duplicate training. This would be especially true—and troublesome—when airmen transfer from one major command to another. Consequently, AF Form 623, On-the-Job Training Record, has been established as one of the methods used to achieve uniformity of training. This form contains a cumulative and consolidated account of an airman's knowledge and proficiency training. The form has five sections, which are individually identified by purpose. This approach permits the recording of all training achieved in job proficiency development, in career knowledge development, and in formal courses. The form is also used to record qualification training which occurs after upgrading has taken place.

The AF Form 623 becomes an official and permanent part of each individual's training record. Because the AF Form 623 must be readily available to the supervisor, it is normally kept in the immediate working unit, though it may be maintained in a centralized location. When an airman is transferred, his On-the-Job Training

Record must accompany him to the gaining organization. The airman's training is expected to continue at this next assignment, unless he is specifically withdrawn by the gaining organization.

AF Form 623 entires. Entries in the AF Form 623 are made with a typewriter, ink, or pencil, depending upon the entry. The form is completed as follows:

a. Section I, Identification Data. On the front page of the form, shown in figure 1-7, you must enter the trainee's last name, first name, middle initial, grade, social security number (SSAN), primary AFSC, duty AFSC, and training to AFSC, date entered training, and general AQE score. Enter the date for the supervisor's evaluation, the commander's evaluation, and the maximum training dates only when the individual trainee enters upgrade training or retraining. In order to determine the date for supervisory evaluation, date for commander evaluation, and maximum training date, refer to AFM 50-23, *On-the-Job Training*. Also, in this section you must enter the estimated training completion data.

SECTION I		IDENTIFICATION DATA			
LAST NAME - FIRST NAME - MIDDLE INITIAL		PAFSC	DATE ENTERED TRAINING	GENERAL AQE SCORE	DATE FOR SUPERVISORY EVAL
DUCKWORTH, DONALD U.		42334	17 SEP 76	45	16 MAY 77
GRADE	SSAN	42354	ESTIMATED TRNG COMP DATE		DATE FOR COMDR EVAL
A1C	478-66-7612	42354	16 MAR 77		16 SEP 77
					MAXIMUM TRAINING DATE
					16 MAR 78

Figure 1-7. AF Form 623, On-the-Job Training Record, Section I.

ON-THE-JOB TRAINING RECORD

SECTION II		ORIENTATION GUIDE AND CERTIFICATION RECORD	
IMMEDIATE SUPERVISOR (GRADE AND NAME)		BRIEFES YOU ON SECTION TRAINING PROGRAM AND EXPLAINS THE FOLLOWING	
TSgt CHASER, BOB L.		a. YOUR APS DESCRIPTION. APM 39-1 b. TRAINING REQUIREMENTS. APM 50-23 AND JPO c. UPGRADING AND PROMOTION. APM 39-29 d. APPRENTICE KNOWLEDGE TEST (AKT) PROCEDURES. APM 33-1 e. PROFICIENCY TRAINING. APM 50-23 f. EXPLAINS USE OF AF FORM 623, STS AND JPO. APM 50-23 g. CERTIFIES COMPLETION OF JPO TASK ITEMS. APM 50-23	
TRAINEE SIGNATURE		I CERTIFY THAT THE ACTIONS LISTED ABOVE HAVE BEEN ACCOMPLISHED AND THAT I UNDERSTAND MY INDIVIDUAL RESPONSIBILITIES FOR CAREER PROGRESSION, AS ESTABLISHED IN APM 50-23.	
Donald V. Duckworth			
SIGNATURE AND TITLE OF CERTIFYING OFFICIAL		I CERTIFY THAT THIS AF FORM 623 IS A COPY OF PERTINENT DATA CONTAINED IN A PREVIOUS AF FORM 623.	

FORM
AF MAR 74 623

Figure 1-8. AF Form 623, On-the-Job Training Record, Section II.

b. Section II, Orientation Guide and Certification Record. When the immediate supervisor enters his name and grade in the appropriate block, it constitutes certification that the action listed opposite the block, seen in figure 1-8, has been performed. The trainee signs in the appropriate block when he is entered into upgrade training. If the AF Form 623 is reaccomplished, the certifying official signs in the block titled, "Signature and Title of Certifying Official."

c. Section III, Reading Achievement Test. Consult AFM 50-23 to determine the necessity for this test and enter the results in section III, figure 1-9, if applicable.

d. Section IV, ECI/CDC Participation, Etc. Enter all CDC, ECI, and other correspondence courses satisfactorily completed in Section IV, figure 1-10. In column A enter the course number and title, in column B, the total number of volumes in the course; and in column C, the date on which the course was satisfactorily completed.

e. Section V, Technical and Supervisory Training. List all technical and supervisory courses satisfactorily completed in Section V, figure 1-11. The usual entires are formal technical schools, but may include FTD courses, training management classes, NCO Leadership School, etc.

f. Entry Restrictions. Entries in the AF Form 623 are restricted to permanent training entries only. Items of a temporary nature, such as required progress evaluation, counseling, etc., are entered on AF Form 623a (see fig. 1-12). Appropriate entries on the form include, but are not limited to:

- (1) Name, grade, data, and action taken as a result of evaluations required by AFM 50-23.
- (2) Dates of time periods and circumstances under which completion of training objective was delayed.
- (3) Appropriate information to indicate that the trainee is not enrolled in the required CDC and why.
- (4) Continuation of any section in the AF Form 623 that has been completely filled up.

SECTION III		READING ACHIEVEMENT TEST	
PART I (DATE AND SCORE)		PART II (DATE AND SCORE)	
26 MAY 76		45-8	

Figure 1-9. AF Form 623, On-the-Job Training Record, Section III.

SECTION IV						ECI/CDC PARTICIPATION, ETC		
A		B	C	A		B	C	
COURSE NUMBER & TITLE		NUMBER OF VOLS	DATE COMPL MONTH & YEAR	COURSE NUMBER & TITLE		NUMBER OF VOLS	DATE COMPL MONTH & YEAR	
CDC 42354		5	FEB 77					
PNEU DR AUL ACHT								

Figure 1-10. AF Form 623, On-the-Job Training Record, Section IV.

SECTION V		TECHNICAL AND SUPERVISORY TRAINING	
COURSE NUMBER AND TITLE	DATE COMPL	COURSE NUMBER AND TITLE	DATE COMPL
3ABR42334 PNEUMATIC MEN 10 AX-76			

Figure 1-11. AF Form 623, On-the-Job Training Record, Section V.

ON - THE - JOB TRAINING RECORD CONTINUATION SHEET (USE REVERSE FOR REMARKS)	SECTION	PART
: INITIAL EVALUATION INDICATES		
TRAINING REQUIRED TO MEET ASSIGNED DUTIES.		
Buck L. Chance		
LAST NAME - FIRST NAME - MIDDLE INITIAL DUCKWORTH, DONALD U.	SSAN 428-66-7612	

AF FORM 623a JUN 74 PREVIOUS EDITION WILL BE USED.

Figure 1-12. AF Form 623a, On-the-Job Training Record, Continuation Sheet.

Exercises (010):

Name both the form and the specific section where each of the following entries would be made in an airman's training record.

1. The date of a counseling session on the airman's progress.
2. The date the airman completed CDC 42354.
3. The airman's SSAN.
4. The name of the certifying official.
5. The airman's score on the Reading Achievement Test.
6. The airman's General AQE score.
7. The number of volumes in CDC 42354.

011. Specify selected procedures for annotating an STS/JPG.

This segment discusses the Specialty Training Standard (STS) and the Job Proficiency Guide Continuation Sheet—in that order.

Specialty Training Standard. The STS is based on the specialty description for the AFS contained in AFM 39-1. It is an itemized breakdown on the tasks and minimum proficiency levels and shown in figure 1-13. Proficiency codes given in the AFSC columns beside each task provide the information given in figure 1-13. These codes are defined in the proficiency code key that is found in each STS. The code key provides a suitable means for achieving Air Force-wide standardization. When an annotated STS is inserted in the AF Form 623, it becomes an official part of that training record, and is called a JPG (Job Proficiency Guide).

For your training records to be complete, there must be a Job Proficiency Guide in your 623. Your immediate supervisor is responsible for annotating and maintaining this JPG.

Annotating an STS. On the inside cover of each STS is a block used for identification purposes (see fig. 1-14). This block has a section for both the trainee and his immediate supervisor. In the trainee's name section, print the trainee's last name, first name, and middle initials. In the Initials (In Writing) section, have the trainee write his initials as if he were signing his name. Then enter grade organization. In the Immediate Supervisor's Name and Initials (In Writing) section, the supervisor enters his name and initials. The extra spaces are for a change in the trainee's supervisor.

Refer to figure 1-13 again. Notice that this page of the STS includes four essential elements:

- A list of tasks.
- Study references for each task.
- Required proficiency levels (work standards) for all tasks.
- Space for both supervisor's certification and trainee's acknowledgment.

The supervisor decides which tasks apply to your present duty assignment and circles in pencil the "proficiency level," in columns 2A, 3A, or 4A, depending upon which level of training is being assigned. As an example, if you are being trained to the 5 skill level, the supervisor will circle the "proficiency level" in column 3A. To keep track of your proficiency training, the supervisor will enter in pencil, the date training begins on a particular task. Later, when you become proficient, the supervisor will enter the date completed and his initials to verify that training on that task has been complete. He will also have you initial the STS to show that you are aware of your training progress. These initials must agree with the initials in the identification section that has been discussed previously.

In many instances, the STS will not cover all of the "locally assigned tasks" an individual might be required to perform at various bases. The "locally assigned tasks" are those duties the airman performs but which are not identified on the STS. Add these items to the STS by using a Job Proficiency Guide Continuation Sheet, AF Form 797, as seen in figure 1-15.

Job Proficiency Guide Continuation Sheet. The Job Proficiency Guide Continuation Sheet supplements the annotated STSs only by adding tasks and will never duplicate tasks already listed in the STS. As an example, tasks associated with the "cargo door and ramp system" are not covered in the STS; so they will have to be placed on the AF Form 797. The STS may contain as many as 150 or more separate tasks, but if the airman currently performs only 20 of these tasks, plus 5 locally assigned tasks, his JPG will be annotated to reflect those 25 applicable items only.

T. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A	B	C	A	B	C	A	B	C
	AFSC/Crs	Date QJT Started	Date Completed & Trainee's Supervisor's Initials	AFSC	Date QJT Started	Date Completed & Trainee's Supervisor's Initials	AFSC/Crs	Date QJT Started	Date Completed & Trainee's Supervisor's Initials
19e. Bench check components	1b/-			2b			3c		
f. Repair components	1b/b			2b			3c		
g. Troubleshoot malfunctions	1b/b			3b	1 May 77	5 May 77 JOD BLM	3c		
20. SHOP, TEST AND AEROSPACE GROUND EQUIPMENT									
SR: Applicable Equipment TOs									
a. Shop equipment									
(1) Hose cutoff machine									
(a) Operate	2b			3c	5 May 77	6 May 77 JOD BLM	3c		
(b) Maintain	1b/-			2c			3c		
(2) Hose assembling machine									
(a) Operate	2b			3c			3c		
(b) Maintain	1b/-			2c			3c		
(3) Hydraulic test stands									
(a) Operate	2b			3c			3c		
(b) Maintain	1b/-			2c			3c		
(c) Connect to components being tested	2b			3c			3c		
(d) Troubleshoot malfunctions	1a/-			2b			3c		
(4) Ultrasonic cleaner									
(a) Operate									
(b) Maintain									
(c) Clean wire elements									
(d) Test wire elements									
b. Aerospace ground e									
(1) Portable hydr stands									
(a) Operate									
(b) Connect t									
(2) Pneumatic ser									
(a) Operate									
(b) Connect t component									
(3) Hydraulic ser									
(a) Operate									
(b) Connect t									
(4) Hydraulic Jack									
(a) Operate									
(b) Maintain l components									

PROFICIENCY CODE KEY

TASK PERFORMANCE LEVELS	1	DEFINITION: The individual
	2	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	3	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	4	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

Figure 1-13. Specialty Training Standard.

THIS BLOCK IS FOR IDENTIFICATION PURPOSES ONLY		
TRAINEE		
NAME DUCKWORTH, DONALD U.	INITIALS (In Writing) D.U.D.	GRADE A1C
ORGANIZATION 4315TH CCIS		
IMMEDIATE SUPERVISOR'S NAME AND INITIALS (In Writing)		
N/I W. J. WILLIAMS WJW	N/I	
N/I B. L. CHASER BLC	N/I	
N/I	N/I	

Figure 1-14. Identification block of STS.

Exercises (011):

1. You receive a new supervisor who will continue your OJT. Where would he place his name on the STS?
2. Describe briefly the annotation placed in the 5-level column of an STS to indicate you are going to be trained on that item.
3. Describe briefly how the supervisor shows that your OJT on a specific JPG item has started.
4. You must be trained on the bomb door system of a B-52, which is not contained in the basic JPG. Where would your training be recorded?

012. Clarify the graduate evaluation program by indicating its purpose and that of AF Form 1284 and telling how graduates are evaluated.

The topics on this unit are, in sequence, the graduate evaluation program, methods of evaluation, and results of evaluation.

Graduate Evaluation Program. The graduate evaluation program is used to aid the quality control of formal and Career Development Courses. It serves as a source of information to determine the ability of recent graduates to perform their assigned tasks to the level of proficiency specified in the applicable training standard (STS).

It also determines the extent to which assigned skills are used and the knowledge that is attained or retained by recent graduates. The evaluation gives insight into the need to revise the approved training

standard, resident courses, or Career Development Courses, and to improve training effectiveness and responsiveness to the requirements of the using commands.

Methods of Evaluation. The evaluation of graduates may be conducted in any one of these: (1) field evaluation visits, (2) the CDC Training Questionnaire, (3) the direct correspondence questionnaires, or (4) the Training Quality Report, each of which will be discussed here.

Field evaluation. Personnel from training activities will visit bases within 6 months after the graduates are assigned (within 12 months if graduates are AFRES ANG units). They obtain evaluation data by discussion with the graduates, with their immediate supervisors, and with others having knowledge of the graduates' performance. The applicable training standard is used as the reference to evaluate each graduate's frequency of use and the ability to perform the task for which he has been trained.

Direct correspondence questionnaires. Questionnaires are the least expensive procedure for evaluation. They may be used to collect large samples of graduate information. The validity of data obtained by mailed questionnaires tends to reflect how well it is prepared and distributed. These questionnaires are sent to recent graduates of a formal course and for the graduate's supervisor. In most cases, the questionnaire is designed for completion by the graduate's immediate supervisor. The questions that are asked pertain to graduate qualification in terms of the skills and proficiency levels reflected in the approved speciality training standard.

CDC Trainee Questionnaire. The CDC Trainee Questionnaire is completed by a sampling of the CDC enrollees when they take course examinations. The CDC testing officials collect the forms and

JOB PROFICIENCY GUIDE CONTINUATION SHEET							
PARA- GRAPH NO.	TASKS, KNOWLEDGES AND STUDY REFERENCES	SKILL LEVEL	PROFI- CIENCY LEVEL	DATE OJT STARTED	DATE OJT COMPLETED	TRAINEE INITIALS	TRAINER INITIALS
22A	Operation of Cargo Door and Ramp System SR: 1C-130B-2-3 Chap. VII	3					
		⑤	3C	28 MAY 76	3 JUN 76	DUD	B.L.C.
		7					
22B	Troubleshoot Cargo Door and Ramp System SR: 1C-130B-2-3 Chap. VII	3					
		⑤	3C				
		7					
		3					
		5					
		7					
		3					
		5					
		7					
		3					
		5					
		7					

DATE	JPG/STS NUMBER	PAGE NUMBER
19 Feb. 76	42354 Duckworth, 478-66-7612	14

AF FORM 797
NOV 62

Figure 1-15. AF Form 797, Job Proficiency Guide Continuation Sheet.

mail them to ATC training center within 1 week of administration of the test. If the responses identify problem areas in the CDC, the training activities associated with the CDC will conduct followup evaluations to determine the actions required to resolve them.

Training Quality Report (AF Form 1284). With this form the immediate supervisor may inform the training activity directly when a graduate does not meet the proficiency or knowledge specified for any task listed in the approved Specialty Training Standard. An example, if the immediate supervisor should observe that a graduate from a particular technical training course doesn't know the difference between a hammer and a screwdriver, he would check the STS to determine to what level the graduate was trained. If he then feels that the graduate had not achieved this level, he should submit an AF Form 1284.

Results of Evaluation. Responsible agencies analyze and use the information obtained through this program (field visits and questionnaires) to aid in evaluating courses, and, if necessary, to make training revisions. If the information is carefully prepared, and critically analyzed, it can provide constructive information on:

- The ability of recent graduates to perform specific tasks for which they were prepared.
- The specific nature of instructional deficiencies, as seen by the graduates.
- Details of the jobs actually performed by the graduates.
- Instruction not needed by the graduates in their jobs.

Exercises (012):

1. Why is the graduate evaluation program needed?
2. Give four methods of evaluating under the graduate evaluation program.
3. What is the purpose of the AF Form 1284?

Security

EVERY DAY you or some other specialist crawls into an aircraft cockpit or fuselage to work. You may not have any classified information that you work on, but some of the systems in the aircraft may be classified. You see and work around these classified systems, and although you don't know it at the time, you have had access to classified information. Later, after you have finished the job, you go to the snack bar to get something to eat. While there you meet a friend who is sitting with a group. He introduces you to everyone and asks you to sit down. Everyone likes to look impressive, especially in front of a group. So to build your ego, and improve your image, you start talking about the small insignificant tidbit of information that you saw while working on the aircraft that morning. Sound familiar!

This particular chapter is broken down into four areas that affect you as a pneumatic specialist. They consist of Information Security, Communications Security, Physical Security, and Operational Security.

2-1. Information Security

DOD 5200.1-R, *Information Security Program Regulation*, which is supplemented by AFR 205-1, *Information Security Program*, explains how to classify, mark, and safeguard official information that requires protection. Classified information can be in many forms, such as documents, manuals, test equipment, drawings, and maps. Obviously, the importance of the classified information determines the manner and extent of its protection.

013. Indicate whether given hypothetical situations include classified or unclassified information.

Classification of Information. Within the Federal Government some official information exists about which we must act with restraint because it concerns the security of our Nation and the safety of our people and our allies. To protect against actions hostile to the United States, it is essential that such official information be classified and given only limited dissemination. The use and

application of security classification is limited only to that information that is truly essential to national security. Basically, the U.S. Air Force has two types of information: (1) classified and (2) unclassified. The latter is subdivided into two types, also.

- **Classified information.** This is official information that must be protected from disclosure in the interest of national security.

- **Unclassified information (of possible intelligence value).** This includes information that is in direct support of classified information. It could contribute to the knowledge of classified information. Also, it would be of intelligence value if it could be associated with other unclassified information, and therefore, reveal an insight into classified information.

- **Unclassified information.** This is official information that is harmless.

Let us now take a look at some examples of unclassified information which may or may not be of intelligence value.

Situation: You are assigned to the 161st Fighter Wing.

Intelligence value: By itself, this information is not of intelligence value.

Situation: Your shop maintains the parts for a unit that is testing a new weapons system for aircraft.

Intelligence value: This information is unclassified information of intelligence value because the testing of new weapons is classified.

Situation: You are assigned to a unit that processes casualties from a combat zone.

Intelligence value: By itself, this information is not of intelligence value.

Situation: A telephone conversation from a supply sergeant at a base in the Far East to a supply sergeant at Langley AFB, Virginia, included a discussion about setting up the required stock level of spare parts for a particular aircraft towing tractor.

Intelligence value: Normally, information about stock levels of spare parts is unclassified. In this case, however, setting up a stock level of spare

parts for specific support equipment would lead someone to suspect future assignment of the type of aircraft for which that aircraft towing tractor is used. Information about the planned assignment of some specific aircraft to specific bases is classified: so portions of the conversation have intelligence value.

Situation: The ground controller at a civilian airport requested the pilot of an experimental aircraft to report when he reached 40,000 feet. The pilot responded as requested.

Intelligence value: The information requested did not reveal or support classified information; therefore, it has no intelligence value. Suppose, however, that the ground controller had requested the pilot to report at 20,000 feet and again at 40,000 feet. If the pilot responded to this request, he would be giving information of intelligence value. Someone could compute the time from one altitude to another.

Therefore, unclassified information is also subject to certain degrees of control. Many small bits can be assembled into one large picture. It is much like a picture jig-saw puzzle. Hours of effort on a puzzle will result in a beautiful picture. You find that by looking at size, color, and shape, you can find the missing part. The same is true of our national secrets.

Exercises (013):

Read the following situations carefully and indicate whether the information is classified or unclassified.

1. SSgt Holmes was at a local restaurant with a couple of friends. They were discussing the master menu for the dining hall.
2. MSgt Green was at a drive-in movie with his girl friend one evening. They were discussing the type of weapons being loaded on aircraft at the base.
3. The Air Force is sending Captain Smith to an area of undeclared war.
4. Captain Smith is a demolition expert.
5. Captain Smith is a demolition expert and is being sent to an area of undeclared war.

014. Specify the level of security classification that should be assigned a prescribed piece of information.

Categories of Classified Defense Information. Defense information may be of varying degrees of value to foreign governments and enemy forces. If its unauthorized disclosure would damage the defense interests of the Nation, or if its possession would afford enemy forces an advantage that would be detrimental to our national security, the information may be classified according to the degree of protection necessary to safeguard it.

Three categories are authorized to designate official information that require protection in the interest of national security. In descending order of importance, these categories are Top Secret, Secret, and Confidential. No other designation may be used to classify defense information.

Top Secret. The designation Top Secret is given to official defense information that requires the highest degree of protection. It applies only to information or material that is most important to national security; that is, its authorized disclosure could result in *exceptionally grave damage* to our national security. Several examples that could be assigned a Top Secret classification are as follows:

a. A strategic plan documenting the overall conduct of a war.

b. War planning documents that contain worldwide information concerning planning data and wartime planning factors for the use of nuclear weapons.

Secret. Official defense information or material, the unauthorized disclosure of which could result in *serious damage* to the national security, is classified as Secret. Several examples that could be classified as Secret are these:

a. A war plan or complete plan for a future war not included under Top Secret.

b. Specific information which, by itself, reveals the military capabilities or state of preparedness of the Air Force.

c. Particulars of scientific or research projects that incorporate new technological developments having direct military application or relating to national security.

Confidential. Confidential refers to that national security information or material which requires protection. The test for assigning Confidential classification shall be whether its unauthorized disclosure could reasonably be expected to cause *damage* to the national security. Several examples that could be classified as Confidential follow:

a. Documents and manuals containing technical information used for training, maintenance, inspection of classified munitions.

b. Research, development, production, and procurement of munitions.

For Official Use Only. The term "For Official Use Only" is not a category of classified information but refers, instead, to unclassified information that may be withheld from widespread distribution to the public. "For Official Use Only" information might reveal an insight into or specifics about some other plan or project. Although unclassified it could be "of possible intelligence value." What we are really saying is that, by putting enough unrelated and unclassified material together, someone might begin to learn about a truly classified project.

Exercises (014):

1. What classification would be on a technical order pertaining to the pneumatic brake system of an aircraft that has been in the Air Force inventory for 10 years?
2. What classification would be applied to research papers that outline the development of a new military laser rifle?
3. How would information pertaining to the conduct of a war be classified?
4. You know that the armament system of a newly designed aircraft is classified. While in the orderly room you notice TOs with titles concerning this aircraft's munitions inspection.

What minimum classification should be assigned the TOs?

015. Distinguish between correct and incorrect statements about the criteria for access to classified information, indicating why the latter are false.

Here we go into the need-to-know principle and security consciousness—in that order.

The Need-to-Know Principle. No one is entitled to knowledge or the possession of classified material by virtue of his rank or position alone. Instead, such material is given only to individuals who are authorized and whose official duties require such knowledge or possession. The fact that you possess a security clearance does not authorize your admittance to any or all restricted areas, nor does it give you access to all classified documents. You must have a valid need-to-know. In other words, this need-to-know principle says that you get access to only that information required for your adequate job performance.

The responsibility for determining whether or not a person's duties require access to classified material rests with the individual who has classified material in this possession. In this regard, look at figure 2-1. If you have a classified document in your possession, you are responsible, and you must determine who has a valid need-to-know. This is *your* responsibility, *not* that of the unit security officer or anyone else. You are not to disclose classified material unless specifically authorized to do so. An individual should not have "access" to classified material just by being physically present



DOES HE NEED TO KNOW?

Figure 2-1. Does he need to know?

where such material is kept. Security measures must be such as to prevent a person from gaining knowledge of information merely by being in the area. Accordingly, classified material is protected by everyone's following this three-part rule: Give classified material only to persons

- Whose official duties require a need to know.
- Who have been granted a security clearance of the appropriate level.
- Who have the proper identification.

Security Consciousness. Safeguarding classified materials is everyone's responsibility. It is the responsibility of all military and all civilians affiliated with the Air Force regardless of their rank. You must be conscious of the security elements involved in the routine discharge of your duties. The protection and security of classified material must be an integral part of each task and not an additional imposed burden. Security requires alert performance by everyone in the chain of command from the commander down to the newest recruit.

Each individual must possess a complete understanding of the security aspects of their organization. The organizational requirements determine what security measures must be taken to safeguard military information. Your organization may have problems for which no regulation gives an answer. In such cases, local directives (supplements) are published to direct the specific methods and procedures needed to provide the required security.

Supervisors should brief their personnel on security regulations and instructions that pertain to the organization and the individuals job; especially DOD 5200.1-R and AFR 205-1. When a person is granted access to classified information, he must be trained to safeguard it properly. Training is an important factor in the security program; security cannot be maintained without it. Although the contents of the security training program is determined by the unit security officer, the supervisor's interest and emphasis affects the program to a great extent. Your personal contribution to the program is a definite indication of your security consciousness.

There is no person or publication in the Air Force that can identify each and every case. You must exercise good judgment based on a thorough study of security requirements and procedures.

Exercises (015):

Below are some true and false statements. Indicate each true statement by placing a T in the blank provided and each false statement by placing an F there. Correct each wrong statement. NOTE: You may have to cross out some words and add some to change a false into a true statement.

- 1. The person that removed the classified material from the file is responsible for determining whether or not a person can have access to it.
- 2. In order to get access to classified material you must have a valid need-to-know.
- 3. Local directives can be published to direct specific methods and procedures needed to provide the required security for which the existing regulations give no answer.
- 4. Safeguarding classified material is the responsibility of the military personnel.
- 5. The need-to-know principle says you get access to only the classified information required for job performance.
- 6. The contents of the security training program is determined by the supervisor.
- 7. The security program of a unit will be affected by the supervisor's interest and emphasis.

016. Given statements on marking and using classified information, identify them as correct or incorrect and alter false statements to make them true.

Identifying and Safeguarding Classified Material.

The safeguarding of classified material deals with the handling, storage, and transmission of classified military information. This information may be in the form of documents, messages, or equipment. You must be concerned not only about the final product but also about carbon copies, rough drafts, and even paraphrases of the original. These must also be handled in the same way as the originals. Obviously, you must be able to recognize classified material when you come in to contact with it. In accordance with DOD 5200.1-R and AFR 205-1, all classified documents and other materials are

clearly marked to indicate their classification category. For most documents, the overall classification is conspicuously marked or stamped at the top and bottom on the front cover, if any. Look at figure 2-2 as you study this.

Individual pages of documents are conspicuously marked or stamped (at the top and bottom) with their appropriate classification. Classified material other than documents are also marked so that their classification is clearly visible and apparent to the user.

DOD 5200.1-R supplemented by AFR 205-1 states that the possession or use of classified material is to be limited to locations where the material can have secure storage and protection. When you have removed them from storage for

working purposes, you must keep them under constant surveillance. When not in use at the moment, you must see that they stay face down or are covered. An excellent precaution is to put them away in their normal storage containers whenever they are not in immediate use.

Exercises (016):

Below are some true and false statements. Each incorrect statement has to be made correct by an added word or words. Indicate each true statement by writing T by it and each false statement by writing F there. For each wrong statement, tell why it is false.

TOP SECRET

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, D.C.
20314



REPLY TO
ATTN OF SPIB

1 May 1975

SUBJECT Letter of Transmittal for Classified Documents (U)

TO: TAC/SP

1. This letter illustrates requirements for preparing a letter used to transmit classified documents.
2. (TS) At the top and bottom of the transmittal letter mark the highest classification of any information in the letter itself or in any of its attachments.
3. If the letter itself contains classified information apply paragraph markings as shown in paragraph 2 above.
4. If the letter itself does not contain classified information you should apply paragraph markings as shown in the subject heading above.

FOR THE CHIEF OF STAFF

DONALD U. DUCKWORTH, Major General, USAF
The Chief of Security Police

TOP SECRET

(THIS SAMPLE LETTER IS UNCLASSIFIED)

Figure 2-2. Markings on classified material.

- 1. A Top Secret document must have the words "Top Secret" marked or stamped on the top, bottom, and both sides of the front cover.
- 2. When classified documents have been removed from storage for working purposes, they must be watched closely.
- 3. On page 3 of a Secret document, the word "Secret" must be marked or stamped at the top and bottom of the page.
- 4. A classified document that has been removed from storage must be placed face down, covered, or displayed if it is left alone for a moment.

2-2. Communications Security

Now that we have covered most of the rules of security, let's discuss the area where we are most likely to violate good security practice. We have discussed the fact that you are the backbone of the security program. If you do not divulge the classified information you know, then our enemies are short one source. Already you know that you should not discuss your knowledge with any unauthorized person. In fact, the best thing for you to do is to talk shop only at the shop. In fact, the easiest place to compromise the complete security bit is over the telephone. Everyone, at some time or other, gets confronted with the situation where an urgent need to get the job done seems to indicate that security procedures should be bent just a little. Don't you believe it! Communication security is one of the strong efforts of the security program one of the strong efforts of the security program and should be one of your prime areas of training and concern. Be certain to use only the authorized methods of communications.

017. Associate methods of transmission of classified material with selected situations where each may be applied.

Topics discussed here include, in order, Air Force communications methods and selecting the correct communications method.

Air Force Communications Methods. In addition to radio and the ordinary telephone (which we discuss later), five methods of communication are

used frequently by the Air Force. Three of these methods are electrical transmissions, as follows:

1. AUTODIN (automatic digital network).
2. AUTOSEVOCOM (automatic secure voice communications).
3. AUTOVON (automatic voice switching network).

The other two methods are these:

1. ARFCOS (Armed Forces Courier Service).
2. US Postal Service (USPS) mail.

We shall discuss each of these methods briefly and explain whether they are to be used for transmitting classified material.

AUTODIN. AUTODIN is a communications network for the transmission of logistical, operational, statistical, and administrative messages. The messages can be encrypted; therefore, the network can be used for classified or unclassified messages of intelligence value. This system automatically produces copies of the messages.

AUTOSEVOCOM: AUTOSEVOCOM is a secure communications network. This system is a long-distance telephone and radio network and is used for worldwide communications between military establishments. It provides for protection of classified or unclassified information of intelligence value.

AUTOVON: AUTOVON is an unsecure communications network. This system is also a long-distance telephone and radio network used for worldwide communications between military establishments. However, it does not provide protection for classified or unclassified information of intelligence value. Never use this system to transmit any information of intelligence value.

ARFCOS. ARFCOS is a communications method that uses selected personnel as messengers. These messengers are used to receive, transport, and deliver classified documents and equipment to United States installations around the world.

US Postal Service. US Postal Service mail includes both regular and registered mail. Registered mail can be used, under certain conditions, to transmit classified material; regular mail does not provide for protection of classified material.

Selecting the Proper Communications Method. When any information is to be transmitted, you must consider the security, speed, and reliability of the method to be used. Both the advantages and disadvantages of each method must be weighed. Let us now take a look at some examples:

Characteristics of ARFCOS.

- a. Speed: One-day delivery within the United States; 1 to 3 days overseas.
- b. Security: Secure; under armed guard while in transit.

c. Reliability: Reliable; correspondence is always receipted for.

Characteristics of US Postal Service (registered).

a. Speed: Slow; 1 to 3 days within the United States; 3 to 7 days overseas.

b. Security: Limited security because of special handling.

c. Reliability: Can be used under certain conditions because of the receipt system.

Characteristics of US Post Service (regular).

a. Speed: Slow; same as registered mail.

b. Security: Insecure; handled by many persons without a need-to-know.

c. Reliability: Unreliable, no receipt system.

Each of the five methods of communications can be considered slow or rapid in relation to the others. Each can also be considered secure or insecure in relation to the others. Take a look at figure 2-3 and see how the five methods compare with one another.

Let us now look at a couple of hypothetical situations. They will involve the transmission of information and the best method suited for the situation.

Situation: A sergeant who was TDY at Wright-Patterson AFB encountered a technical problem involving the weapons system of a new fighter plane. He wanted to get in touch with his home base to help solve his problem. The information that he needed was classified, and an answer was needed as soon as possible. He decided to call his home base on the AUTOVON. Was he right or wrong in his decision?

Because he required classified information, he was wrong in his choice of AUTOVON. If you recall, AUTOVON is an insecure communications network. It could be tapped quite easily. He should

have used AUTOSEVOCOM, which is a secure voice communications network.

Situation: An airman had just completed an extension course. He had a question concerning the manner in which air compressors were presented in the text. He decided to send an inquiry to ECI headquarters through regular US Postal Service mail channels. In this case, regular USPS mail was the most feasible method to use. The airman was not pressed for time and no classified information was involved.

Exercises (017):

Specify the proper method of transmission for each situation given in column A by placing the letter of its corresponding type of transmission, found in column B, in the blank alongside its related situation. NOTE: Each item in column B may be used once or not at all.

Column A Situations		Column B Types of Transmission
— 1.	A 300-page document classified Secret has to be distributed to all European Air Force Bases within 1 week.	a. AUTODIN.
— 2.	Within 5 hours, Captain Ecker has to have a classified single-page message in the hands of three base commanders in a war zone.	b. AUTOSEVOCOM.
— 3.	A civilian employee for a Nuclear Arms Development center must transmit some classified information to another base immediately.	c. AUTOVON.
— 4.	You have a request for an "FOR OFFICIAL USE ONLY" document from Scott AFB, IL.	d. ARFCOS.
— 5.	You have 24 hours in which to send a Secret document to a base which is 200 miles away. The document consists of a 3-volume, 500-page report.	e. US Postal Service.

SLOW	FAST		SECURE	INSECURE
x		ARFCOS	x	
	x	AUTOVON		x
	x	AUTOSEVOCOM	x	
	x	AUTODIN	x	
x		U.S. MAIL		x

42-994

Figure 2-3. Air Force communication methods.

- 6. The Wing Intelligence Officer sends short intelligence reports to three different bases each day. These reports contain information ranging from Top Secret to unclassified bits of possible intelligence value.
- 7. A 10-page regulation marked For Official Use Only, has been published and must be sent to four different bases. The regulation is effective the day each base receives it.

018. Examine voice communication and telephone security violations by naming the weaknesses of the telephone as a communications mode and associating certain security violations with situations involving voice communication.

First, voice communication; then, common telephone security violations concern us here.

Voice Communication. Voice communication is sending information by any mode that uses voice. Examples of voice communication are commander's call, telephone conversations, radio transmissions, and social gatherings. Because of the frequent use of voice communication, and because much of the official business you conduct involves information of possible intelligence value, you must be thoroughly familiar with the security precautions and

violations associated with voice communication. You must also be security-conscious in all of your daily actions. A basic precept to remember is that the need for protection will generally exceed the need to convey sensitive information.

The communications instrument most frequently misused in regard to security is the telephone. For this reason we shall discuss telephone usage in some detail.

Telephone System Weaknesses. Study figure 2-4 as we discuss these weaknesses. A basic security weakness of telephone usage results from the far-reaching telephone system. Telephone wires, telephone operators, relay stations, radio relays, and the telephone instrument itself are all part of the telephone system. Thus, when you are using the telephone, you may think that there is a direct wire from you to the person with whom you are talking when this is definitely not so. Instead, such uninvited listeners as operators, linemen, and technicians could be "listening in" to your conversation. There is also the possibility of illegal wiretapping. Because electronic devices ("bugs") are readily available to anyone, an unfriendly agent can listen in on telephone conversations with little difficulty.

no human operator or technician at all for your call, but may rely instead on automatic stations and devices for all dialing and switching. Here the chances of your being overheard may seem reduced, but you cannot count on this. You cannot assume that the devices work perfectly 100 percent of the time. Also, even if the devices work, you cannot be sure just how your call has been routed. For



WHO IS LISTENING TO YOUR TELEPHONE CONVERSATIONS?

Figure 2-4. Telephone system weaknesses.

example, some telephone calls over great distances are carried by radio relay, which can be intercepted easily. Other calls may be routed similarly in a very insecure way.

Another security factor that you must keep in mind is the sensitivity of the telephone transmitter or mouthpiece. The telephone transmitter is a sensitive instrument, capable of picking up even your whispers. It can also pick up noises and conversations in the background.

All of these aspects of the telephone system make its use a security risk. When you are telephoning, any number of people, with no "need" or "right" to know sensitive or classified information, can be hearing your conversations. Therefore, you cannot afford to take a chance. Whenever you use the telephone, you must assume that you have uninvited listeners, that some of them are unfriendly, and that none of them has a need and a right-to-know. This means you should not discuss any information that is classified or of possible intelligence value and must take care that all background conversations or noises concerning such information are not transmitted over the telephone.

Common Telephone Security Violations. Because of the telephone system weaknesses, the manner in which the telephone is used may cause security problems. Disclosing sensitive information on the telephone because of unusual circumstances is one very common type of security violation. Another is attempting to disguise classified or sensitive information. We shall discuss specific types of violations below. It is important that you recognize these and other telephone security violations. Keep them from occurring whenever you are assigned.

Being trapped by time. One example of an unusual circumstance that could cause the disclosure of sensitive information over the telephone is being *trapped by time*.

Let's look at a situation that could happen involving this weakness. Suppose you are given the responsibility of delivering some information of possible intelligence value to the first sergeant. There is ample time for you to walk over and tell the sergeant or to send a memo by base messengers. However, you are delayed just as you start to go; so you relay the information by telephone. In other words, you have been trapped by time, and a telephone security violation is the result.

Poor planning is the real culprit in this violation. To avoid the situation of being trapped by time, plan ahead so that you can use a mode of communication that is sufficiently reliable and secure.

Fear or rank or position. Another type of disclosure due to circumstances results from awe or *fear of rank or position*. We are often rightly impressed by the "call from headquarters." But should you be in such awe of this office that you

discuss information of possible intelligence value on the telephone? Definitely not! A typical example of such a risk might be a call you receive from Colonel Emerson requesting some specific information. You think this information is of possible intelligence value, but since it is Colonel Emerson himself, you give the information over the telephone. Your awe of rank or position causes a telephone security violation.

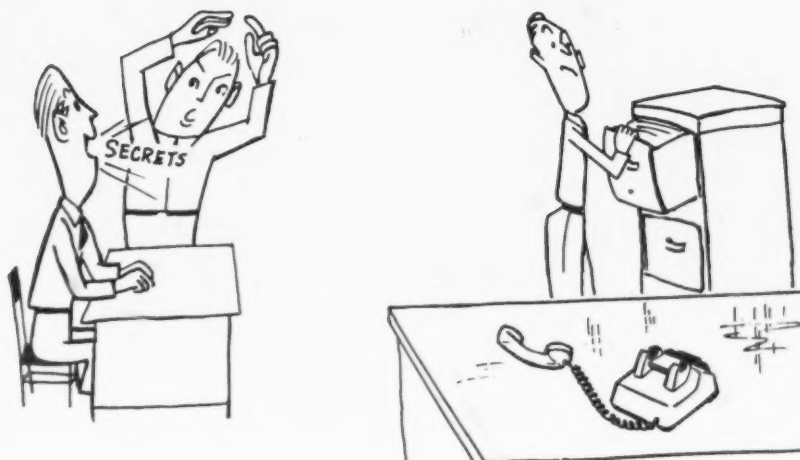
Always remember, regardless of who calls from a higher headquarters, never use the telephone to discuss or provide classified information or information of possible intelligence value.

Conducting personal business. Using the telephone for other than official business is another practice that can lead to the disclosure of classified or sensitive information. Yet, remember, the telephone in your office is there for one reason only: to conduct official business. Accordingly, when you call your girl friend from the office, you are using the telephone for other than official business. If over a period of time your girl friend calls the office often enough to learn the names of everyone in your office, and overhears enough background conversation to find out what goes on in the office, could this be a security risk? Yes, it could be.

"Talk around." One of the greatest security problems arising from use of the telephone is the temptation to talk around classified or possible intelligence value information. This means trying to send the information in such a way as to protect it, yet to get the point across.

"Talk around" is usually easy to recognize. It consists of using words that are not supposed to make sense to anyone except the one for whom the information is intended. Calling a classified part of a radar a "gizmo" might be an example of attempting to talk around. However, no matter how much you change the words regarding a classified subject, the subject is still classified. Any person who would go to the trouble to listen in on your telephone conversations probably would know enough to "read through" your attempts to talk around.

Unclassified gossip. Another type of security risk is unclassified gossip. "Gossip" means chatter or idle, unnecessary talk. Anytime you use an official telephone to "shoot the breeze" with a friend, you are engaging in unclassified gossip. Other times you may find yourself "holding the line" while someone is searching for some information. Look carefully at figure 2-5 in this regard. When you make small talk by asking, "How are things over there?" or "Is old so-and-so still in your section?" you are engaging in unclassified gossip. The security risk arising from unclassified gossip is the ever-present risk of associating persons or subjects with a specific job or section.



UNAUTHORIZED LISTENER ON THE PHONE?

Figure 2-5. Background noises.

Self-made reference systems. Using self-made reference systems to refer to information that is classified or of possible intelligence value is a very definite security risk. You may believe that you are clever enough to refer to an item of information without actually revealing names, subject, etc. but this technique rarely succeeds from a security standpoint. Self-made reference systems may be anything, but a simple one might sound like this: "Well, let's see now. Subtract today's date from the form number 107, and you have the total." Anyone who overheard this conversation could subtract the date from 107 and get the total.

Here are some other examples of using a self-made reference system:

- a. "Next year we are going to be flying the same models that you guys at Hailstrom AFB have."
- b. "The new aircraft will fly as fast as the old F-86."
- c. "Our departure time is classified, but we leave one-half hour earlier than you left yesterday."
- d. "I cannot tell you the payload of the new one, but it is equal to two of the ones you are now flying."

As with "talk around," anyone who would take the trouble to listen in on your conversation would be willing to take the time to read through your "self-made reference system."

Paraphrasing. Another close neighbor of "talk around" is paraphrasing. "Paraphrasing" means changing the words but not the meaning. Some examples of paraphrasing are the following:

- a. "I cannot tell you who the VIP is, but he is the Vice President's boss."
- b. "Our number one boss here will leave for your operations center at 0730 tomorrow."
- c. "Your flowing locks must be abbreviated before regular duty time tomorrow."

The major difference between talk around and paraphrasing is that "talk around" employs invented words or "gobbledygook," while paraphrasing does not. Both techniques are security risks when they are attempts to disguise classified or sensitive information.

Using code words and nicknames. Another method of trying to disguise information in voice communication is the use of code words and nicknames. A code word is a classified word with a classified meaning, while a nickname consists of two words that are classified. When used in Air Force communications, the word "CHICAGO" could be a code word; the word "BURNT MATCH" could be a nickname for an exercises. Both code words and nicknames are valid attempts to disguise in communications, but neither should be used in any telephone conversation.

Emotional outbursts. Displays of strong emotions can be another security risk. If a person becomes impatient, angry, or hasty when using the telephone, he is likely to say something he shouldn't. Have you ever seen anyone try to explain something on the telephone and become angry when he could not get the point across? In

conducting official business, this could be a security risk.

Other voice communication security violations. We are not suggesting that you or any other Air Force member would ever knowingly give to enemies of our country any information that is classified or of possible intelligence value, but many United States citizens do provide such information just by talking too much. We have examined some of the security risks that could occur when you use a telephone. Most of these security risks can also occur in face-to-face conversations at any time or place. Talk around, emotional outbursts, gossip, etc., can run wild at a social gathering. You can avoid such security risks if you simply remember that talking about your work should be confined to your official duties. Never discuss these duties, the place where you work, or the equipment you maintain in a public place or even at a private party. This can best be described by figure 2-6. Develop the habit of avoiding any discussion of your military activities with unauthorized personnel. This habit should be part of your security consciousness as a member of the Air Force team.

Exercises (018):

1. Give the weaknesses of the telephone as a mode of communication for classified or sensitive information.

KEEP QUIET



ZIP YOUR LIPI

Figure 2-6. Zip your lip.

2. Match each type of telephone security violation, column B, with the situation involving it, column A, by placing the number of the violation in that blank alongside the applicable situation. NOTE: Each column B item may be used once or not at all.

Column A Situations	Column B Telephone Security Violations
— a. "On page 7 and 26 of the gizmo, where it reads '8' we need to change it to '10' because of additional workload from your section."	1. Trapped by time. 2. Fear of rank or position. 3. Conducting personal business.
— b. During lunch hour, two airmen were discussing the events of the coming week. One said he would not be able to go fishing Thursday because his section was starting work on a new project.	4. Talk around. 5. Unclassified gossip. 6. Self-made reference system. 7. Paraphrasing. 8. Using code names and nicknames. 9. Emotional outbursts.
— c. You receive a call from a general requesting some specific information. You think the information is of possible intelligence value, but since it is a general in person speaking you give him the information over the telephone.	
— d. Airman Stevens works downtown at a gas station when off duty. One day you hear him use the office phone to call his civilian employer. While Stevens is on the phone, other personnel in the office are discussing classified information.	
— e. During a telephone conversation, you are told, "I can't tell you its speed, but it can fly from New York to Seattle in 1 hour and 50 minutes."	
— f. A monitored radio message has associated the nickname "Red Dog" with a bombing mission.	

2-3. Physical Security

The Air Force Physical Security Program is designed to produce direct and indirect influences that will deter any enemy from initiating hostile operations against the Air Force. This concept is based on the conviction that effective security measures will convince the enemy that tremendous risk, and penalties will result from any attempt to impair Air Force operational capabilities.

019. Clarify Air Force physical security by defining selected terms associated with security and specifying base security measures to discourage hostile attacks.

This LO covers security terms and security measures, in that order.

Security Terms. Before we get into the measures designed to deter security activities, we need to know certain terms. These are as follows:

- Clandestine—Activities conducted in secrecy.
- Sabotage—Any act by an enemy to destroy material, equipment, buildings, etc.
- Espionage—The act of one nation spying on another.

Sabotage and espionage can be conducted in either an overt or a clandestine (covert) manner.

Security Measures. The Air Force knows that every Air Force base cannot be guarded completely from attack by hostile groups. Two things dictate this conclusion: Modern technology's mass destructive weapons and the tremendous cost of maintaining a security force. But, with proper security measures implemented at all levels of command, the Air Force can strongly influence deterrence of clandestine covert or overt activities against Air Force bases. Some of the security measures that can be taken are:

1. Have an effective high-speed security reporting and alerting communications network. This network links all bases so that reports of hostile events and security alerting orders to all bases can be accomplished. Two types of reports in the security reporting alerting system are identified by the standard name of "Helping Hand and Covered Wagon."

a. Helping Hand. This report means that a possible hostile event that could affect the ready general war capability has been detected.

b. Covered Wagon. This report means that a condition exists or an event has occurred at a base as a result of actual or probable hostile action.

2. Establish a security force for armed response to counter hostile threats. The security force must be able to expand into an emergency force by augmenting additional personnel as necessary.

3. Establish a Base Security Plan (OPLAN) providing detailed guidance for the conduct of normal and emergency security operations, with Central Security Control (CSC) as the operational command post.

4. Establish restricted areas, by posting with signs and installing fences with guard posts and towers as check points.

5. Finally, utilize personnel such as you, the pneudraulic mechanic. Yes, you! You can challenge anyone whom you suspect as being a security risk.

Exercises (019):

1. When speaking of terms associated with security, what does "clandestine" mean?
2. What does "sabotage" mean?
3. When "helping hand" is stated, what does this indicate?
4. What two things dictate the conclusion that every Air Force base cannot be guarded?
5. What are the two types of reports in the security reporting and alerting system?
6. What would be established to counter hostile threats on an Air Force base?

020. Identify certain entry control procedures used to verify the authority for each person seeking to enter a restricted area.

In this unit we take up restricted area entry and entry control procedures.

Restricted Area Entry. Basically, personnel entry controls are security measures applied against the threat of physical penetration of a restricted area by unauthorized persons. In establishing an entry control system, the base security planners must keep in mind the fundamental objectives to which the procedures must contribute. In addition, the impact that the procedures will have on operations, maintenance, and similar official activities performed in the restricted areas involved must be considered. The base security planners primarily must establish a system that is effective, but at the same time they must achieve maximum compatibility with the duties, schedules, and work procedures of other personnel. The number of personnel permitted to enter a restricted area will be severely limited at all times. Only the persons absolutely needed to perform essential tasks will be allowed to enter.

Entry Control Procedures. The fundamental objective of any entry control procedure is to verify the authority of each person seeking to enter a restricted area. One or more of the procedures

described below will be used to establish a person's identity and verify his authority to enter a restricted area.

Exchange badge procedure. This technique requires the issuance of two badges. One badge is issued to the person requiring the badge. The second badge—similar to the first except for a distinct color, and only reflecting the number for the area concerned—is held by the restricted area guard. When the person enters or leaves the restricted area, he must exchange his badge for the badge held by the restricted area guard. This proves to be a positive control identification and verification technique.

Single badge procedure. This entry control technique involves only one badge for each person to be controlled. When the possessor of the badge proceeds to an established entry point, an entry guard will examine the badge and compare the photograph and other data with the person's features. Because, by itself, any single badge procedure can be defeated with relative ease, one of the following supporting identification and verification techniques will be employed:

1. **Personal Recognition.** This is a highly valuable security technique when employed as a formal procedure where relatively small numbers of persons are working together.

2. **Signature and Credential Check.** When these procedures are applied, a person will be asked to sign his name which will be compared against his DD Form 2AF, Armed Forces Identification Card, driver's permit, or other credentials.

3. **Telephone or Radio Verification.** This type of verification involves the notification of CSC by a unit dispatching the individual of the person's need to enter an area. CSC will inform the entry guard of the area that an individual will be entering the area.

4. **Sign/Countersign Systems.** This is basically where a specific word is spoken (sign), and in order to gain entry into the restricted area, you must give the countersign.

Exercises (020):

1. What type of procedure is used where the person entering a restricted area gives his badge to the guard and receives a badge from the guard that he must wear?
2. What type of procedures is used if you have to show your badge to the guard, sign your name, and then show the guard your DD Form 2AF, Armed Forces Identification Card, against which he compares your signature?

3. The verification procedure that can be used where relatively small numbers of personnel are working together as a highly valuable security technique is called

4. What verification procedure is used when your shop notifies CSC you need to enter a restricted area, and CSC informs the entry guard of that area that you will be entering it?

021. Concerning the restricted area badge, give its purpose and description and identify selected escort and control procedures.

Restricted Area Badge. The USAF Restricted Area Badge is a serially numbered accountable form and available in several colors. The restricted area badge serves as an official document issued to a person who has been granted unescorted entry authority. The person's photograph and other pertinent identification data must be shown on the badge. A series of numbers is provided to indicate the particular areas on the base for which the person has unescorted entry authority. Unused numbers must be blocked out. If the badge is prepared for a person designated an escort official, a capital letter E will be typed or stamped on the badge to the side of the numbers.

The badge must be equipped with a button tab or snap clip so that it may be attached to the outer clothing of the possessor. The person to whom the badge is issued is responsible for its security. The badge must also always be displayed on the outer clothing when the person is inside the restricted area and must be removed when he is outside the designated area.

Unescorted entry. In determining whether a person qualifies for the granting of unescorted entry authority for a restricted area, the frequency of his being needed in the area along with his security clearance will be the determining factors. Aircraft crew members, mechanics, refueling systems operators, etc., regularly assigned within an area, are typical examples of personnel who could qualify for unescorted entry.

When such a need is established, a person may gain entry either by being granted unescorted entry authority (given a restricted area badge) or by being escorted.

Escorted entry. Escorted entry applies to all other personnel who may be needed within the restricted area but who do not qualify for unescorted entry. This includes personnel requiring entry into a restricted area only on a one-time basis or to perform duties on an infrequent "on call" basis.

Civil engineers, utilities repair crews, and certain staff personnel are examples of such personnel.

Escort officials selected for each restricted area must be strictly limited to personnel who hold responsible supervisory positions for the restricted area in question and who can make valid determinations that there are official needs for persons to enter. Also, the number of escort officials for each restricted area must be kept to an absolute minimum consistent with the demands of essential tasks and operational requirements.

Procedures for escorting personnel. When escorted entry by a person is required, a designated escort official bearing a USAF restricted area badge—one properly annotated for escort authority for the restricted area involved—will meet the person at the area entry point, confirm his need to enter, and insure that he is escorted until departure from the area. An escort official's most important function is to determine whether or not a person should be permitted to enter the restricted area. The escort official assumes the responsibility for the actions of the person while he is within the area, and for his being escorted out of the area when his work has been completed. A person who has been permitted to enter, based on an escort official's authorization, is required to be kept under escort continuously while he is within the area. This can be accomplished by several ways, as follows:

a. The escort official has to keep the person constantly in his company until that person has finished his business and then accompany him back to the entry point.

b. The escort official may specifically designate another person assigned within the area to escort, to remain with the person until he has finished his business, and then to accompany him back to the entry point.

c. If a person is to be involved in tasks at a specific point or zone within the area, the escort official may, upon coordination with CSC, establish a free zone within which the person may work. He must appoint persons in the immediate proximity of the free zone to fulfill the requirements of escort by maintaining surveillance over the person while they themselves continue to perform their own tasks.

In all instances, it is the responsibility of the escort official to explain the rules applicable to movement within the area to persons permitted to enter a restricted area under escort.

Exercises (021):

1. What is the purpose of the restricted area badge?

2. What are the numbers on the restricted area badge for?
3. If the letter E is placed next to the number on the badge, what does this indicate?
4. What qualifies an individual as eligible for being issued a restricted area badge?
5. Who will be selected as escort officials?
6. When an individual is going to be escorted into a restricted area, what is the most important function of the escort official?
7. May the escort official designate another person to escort an individual?

2-4. Operational Security

From preceding discussions of security, you know that classified information must be safeguarded by physical means, by limiting dissemination, and by not discussing classified information in unsecure areas or using unsecure methods of communications. You have learned specific facts concerning communications systems used by the Air Force as well as where unclassified conversations are used to illustrate how information of possible intelligence value to an enemy could be obtained. In addition, your awareness of the fundamentals of security focuses attention on security needed during emergencies and in certain peacetime operations.

In this section, we will describe the Air Force Operational Security (OPSEC) Program. This program promotes the successful execution of mission operations. It is applicable to all peacetime as well as wartime missions.

022. Clarify operational security (OPSEC) by defining it and tell its objectives in your own words.

Subjects in this LO are OPSEC's definition and OPSEC objectives—in that order.

Definition of OPSEC. A simplified definition of operational security would be: "The protection of classified and unclassified information about a military operation that could aid the enemy, if revealed to him."

One of the basic principles of war deals with the element of surprise. OPSEC is concerned with keeping tactical and strategic advantage on our side by protecting information and activities affecting our plans, resources, and limitations. The proper protection of classified information and material is part of it; so is the protection of seemingly trivial or insignificant, unclassified information and actions.

In other words, we must protect information or actions that are "sensitive." The successful accomplishment of the mission is dependent upon each individual recognizing what information and action needs protection, and then providing that protection. However, OPSEC and the overall security measures must not detract from operational effectiveness. There must be a balance between security and mission accomplishment.

OPSEC Objectives. The OPSEC program is conducted on a full-time basis, as is communications security. OPSEC is similar in key elements, such as *individual responsibility* and in the *need-to-know*. An established OPSEC program has four major objectives. These are to:

- Identify those portions of an operation that require protections.
- Develop OPSEC procedures and techniques.
- Systematically assess OPSEC status at all operational levels.
- Document deficiencies and institute corrective actions.

Exercises (022):

1. Use your own words to define "operational security."
2. List three major objectives of OPSEC, doing so in your own words.

023. Examine OPSEC by citing selected factors and activities making the OPSEC program necessary and telling when the need for it was determined.

We will look into, first, the history; then, the background of OPSEC in this segment.

History of OPSEC. The first Air Force OPSEC Program dealt with the problems of combat operations security in Southeast Asia during the 1960's. Its purpose was to prevent the enemy from gaining prior knowledge of our operations by denying him specific information which he could use to decrease our operational effectiveness. In order to protect information, it was applied to any military activity contributing to our combat commitment. Specific information about planned,

current, or completed actions of an activity can give an enemy certain advantages. Security procedures helped identify and eliminate those areas of patterned activity which served to show the enemy something was going to happen.

The present OPSEC program was established in 1970. Later it was expanded to include and protect the information of all personnel and agencies having knowledge of any military operation, event, project, or program. OPSEC is now applicable to those military activities contributing to our national security effort in peacetime as in wartime.

Background of OPSEC. Every manager or supervisor has a responsibility to maintain operational effectiveness at the highest possible level. This responsibility includes the obligation to apply required OPSEC principles and procedures in promoting overall security.

Limited emphasis has been given to the need for a broader, more nearly all-encompassing security program—a program that could prevent certain information about Air Force operations from getting into the wrong hands. Such information could then become valuable to potential or actual enemies by providing prior knowledge of our operations. Protection is provided under the Air Force Operations Security (OPSEC) Program prescribed by Air Force Regulation 55-30, *Operations Security*. This regulation is concerned with the information, actions, and activities that are "sensitive" in the sense that they telegraph our punch to the enemy—they can give him forewarning. We must "keep the advantage on our side."

The success or failure of combat operations is contingent upon the element of surprise. Before an operation can be kicked off, personnel must be assembled, equipment and transportation massed, and numerous other activities completed. Usually definite patterns of behavior or action are followed. These patterns can become warning signs to enemy intelligence collectors. Attempts to gain information about planned operations is not an innovation; it is an age-old practice. A forewarning may provide time to institute countermeasures that reduces or negate the advantages of surprise.

The need for overall security is not limited to major combat operations. Foreknowledge of any combat operation could enable an enemy to disperse, to go into hiding, or to change his offensive tactics. Air Force experience and studies have shown how certain knowledge about operations may be made available to an enemy without violating any security rules. Two examples are the posting of flight schedules where foreign nationals can see them or the establishment of procedures such as standard flight patterns. These can enable the enemy to predict important aspects of a planned operation. Facts about specific activities can be revealed in unclassified

communications. The elimination of these information leaks helps to protect the surprise element in combat operations.

Exercises (023):

1. Specify the major factor that indicated the need of an OPSEC program.
2. Cite activities that could become warning signs to enemy intelligence collectors.
3. When was the necessity of the first Air Force OPSEC program determined?

024. Apply the concepts of the OPSEC program relating to informational, communication, and physical security programs by spotting security or security program violations in typical situations.

Security Programs. Security is the sum total of each individual's adherence to and compliance with sound security practices. Adequate security can be obtained only by effective direction from supervisors, coupled with alert performance of duty by each member of the Air Force.

The Information Security Program provides a categorizing system for information according to its importance. This system has been covered previously in this section (when we talked about classified and unclassified information). We have also covered the categories of classified information, which are Top Secret, Secret, and Confidential. We must all not forget that unclassified information can be of value to the enemy. Bits and pieces of information which may be harmless by themselves can—when compiled together—reveal facts about our plans and operations. Also, the information security program requires that everyone in the Air Force must be informed of his responsibility for protecting classified and unclassified information that he knows or possesses.

The Communication Security Program, which we discussed earlier, too, is designed to deny unauthorized persons information of intelligence value that they may get through any communication media. This means not talking about this information over the telephone or when unauthorized persons are present. The proper transmittal and storage of this matter is also included in this program.

The Physical Security Program deals, as we have said, with the area of security interest in terms of

threats of physical damage to Air Force operational resources. These resources are primarily the aircraft or weapon system, command post and facilities, and weapons (nuclear and conventional). Security Police are not the only ones responsible in this area. Every member of the Air Force must shoulder his share of security responsibility.

As you can see, then, these programs are related to the OPSEC program. Yes, they are different programs with different intermediate objectives. However, the final objective will be to provide an all-encompassing security system.

Exercises (024):

1. Airman Smith worked downtown when he was "off duty." One day he called his civilian employer on the office phone. While he was on the phone, other airmen in the office were discussing information on the type of cold weather clothing to take with them on an upcoming military operation. What security violations occurred here?
2. Sergeant Blabber is on a weapons load team. He knows a sergeant on another load team who is a part-time bartender at the NCO club. At the club, Sergeant Blabber tells him about the bombs his team loaded on the aircraft that flew that morning. They are a new type of bomb that would not explode on impact, but would bury themselves in the ground. They were timed to go off 24 hours later. There are several foreign national club employees within hearing distance. What security programs were violated and how were they violated?

025. Given selected operational situations, determine and state the OPSEC vulnerability described in each.

Applying OPSEC. The Air Force Operations Security Program is centered around the activities of each major command. This is logical because of the difference in operational missions. However, it is often the day-to-day operations within an operating unit that result in an OPSEC weakness.

Shortcuts and timesavers at the working level have proved to be a source of intelligence to the enemy in the past.

There are many types of information regarding an operation that should be protected. Examples of the types of information that require protections are:

- Objectives of the operation.
- Operation time and location.
- Friendly and enemy forces involved.
- Known or suspected limitations.
- Methods of employment.
- Results of the operation.
- Sources of intelligence data.

There are many sources or possible sources of information that forewarn the enemy. To assist in eliminating potential OPSEC weaknesses, this list of indicators is furnished.

Operational Indicators. Four indicators involved here are these:

- Stereotyped sequences of events.
- Coordination with other agencies that do not have proper safeguards for information.
- Stereotyped patterns of flight activity.
- Submission of unclassified reports at specific intervals.

Procedural Indicators. Among procedural indicators are the following:

- Public information releases.
- The posting and/or transmission of orders, flight plans, in unsecure areas.
- The posting in unsecure areas of duty rosters, transportation schedules, dining hall schedules, etc.
- Distinctive emblems or paintings on vehicles, building, or aircraft.
- Markings on supplies, the location or starting date of the operations; that is, nicknames, delivery deadlines, etc.
- Logistic build up or positioning of support materials.
- Special briefings, meetings, or religious services.
- The use of nicknames, since a nickname provides an easily recognizable "flag" for actions associated with a particular operation.
- Testing portions of the plan.

Communications indicators. There are these five communications indicators:

- Plain language communications associated with a planned operation.
- Use of unchanging call signs and/or radio frequencies.
- Stereotyped message characteristics.
- Significant increase or decrease in message traffic volume.
- Activities of new communications facilities.

Exercises (025):

1. Determine which of these situations has an OPSEC vulnerability.
 - a. Using a nickname with all activities involved in an operation.

b. Posting the chow hall menu on the bulletin board.

c. Putting all supply personnel on 12-hour shifts.

d. Notifying motor pool that all of the refueling trucks must be "in commission" by a certain date.

2. Give at least 3 examples of operational information that require protection.

026. Given typical operational situations involving OPSEC, determine the proper action to be taken in each.

OPSEC in Practice. The main objective of OPSEC is to provide necessary security to our operations during the planning, execution, and after-action phases. One of the most important lessons to be learned is the ease with which an actual or potential enemy can obtain foreknowledge of our operations. Foreknowledge gives him an advantage that has been ours.

Standardized practices reveal information concerning the what and how of actions to take place. The tendency to "get the word out" to everyone interested in the operation detracts from the basic security principle of need-to-know. The individual at the working level should become aware of the intelligence impact that his information and activity have. It is quite easy to see this in the combat operations situation. What of peacetime operations and projects? To answer a question, "Why make the opportunity available?"

In the shop where you work, bits of information may be passed around concerning an operation. A successful operation requires that you be given enough information so that you can make preparations. There may be shifts to change, parts to order, and equipment to pack. An operation may require that you go TDY. You may need someplace to store your car. You may need someone to look after your family. You may have to pay some bills. Remember, information concerning this operation should not be revealed to

unauthorized persons, including your wife, mother, or girl friend. (See fig. 2-6.)

In another situation, operational readiness inspections (ORIs) reveal capabilities of organizations which could be of significance to the enemy. Do not discuss these facts with others. A careless act, just plain ignorance, or a few words spoken in an unguarded moment may turn you into an involuntary espionage aide. All of us must be conscious of security responsibilities daily. You as an individual are the key element in any security program.

Exercises (026):

1. Your shop is notified to ship a special tester, used on the newest Air Force fighter, to Greece for 89 days. What should you do with this information?
2. Several men in your shop have experience on reconnaissance type aircraft. They are all notified they are going TDY to Korea in July. What should you do with this information?

Air Force Publications

HAVE YOU ever started to do a job when you didn't have any idea how to do it, where to start, or what you needed to complete it? This is where Air Force publications can come to the rescue. They can save you much time and energy. Why should you stumble and fumble, making up procedures that others have already worked out? It is to your advantage to learn about these publications and how to use them. During your military service these publications will be a great help to you.

Two types of publications that are pertinent to your job are standard publications and technical order publications. The primary purpose of standard publications, such as regulations and manuals, is to announce policies, procedures, instructions, and information of general interest.

Technical orders contain technical information pertaining to the maintenance of Air Force equipment and materials.

As a specialist, you will use technical order publications more often than standard publications. Nevertheless, you should become well acquainted with all of the types of Air Force regulations, manuals, indexes, and other basic references that you will also need to perform your work. In this section, we shall examine the types of Air Force standard publications. Then, in the second section of this chapter, we'll proceed with a survey of the Air Force technical order system.

3-1. Standard Publications

Commanders and staff officials at all organizational levels in the Air Force have a continuing need to communicate written policies, procedures, and information of their personnel. They do this through letters, messages, and standard publications.

Standard publications announce policies, assign responsibilities, prescribe procedures, direct actions, and inform or motivate personnel. The standard publications system includes eight types of publications. There are: (1) regulations (which include the numerical indexes to publications), (2) manuals, (3) pamphlets, (4) operating instructions, (5) visual aids, (6) bulletins, (7) staff digests, and (8) supplements to publications. Air Force Regulation

(AFR) 5-1, *Air Force Publications Management Program*, is the reference for standard publications.

027. Analyze standard publications by specifying the general classes and describing various types of standard publications.

Types of Standard Publications. Standard publications may be divided into two general classes: departmental and field. Departmental publications are issued by (or for) Headquarters USAF. They apply to the entire Department of the Air Force. All departmental publications will begin with the letters AF, which identify it as being issued by Headquarters USAF. Field publications are issued at major command level or below for use within the issuing organization. Examples of field publications are Tactical Air Command Regulations (TACRs), and Air Training Command pamphlets (ATCPs). The abbreviations of the major command appearing on the publications identifies them as field publications.

Let's look at these standard publications and their specific uses.

Air Force regulations (AFRs). Regulations contain directive and policy material and assign responsibilities. They may include brief procedure details when necessary. Regulations are usually permanent in nature. When it is known that a regulation will cease on a specific date, the expiration date is included. Air Force regulations are the most numerous of all Air Force standard publications.

Air Force manuals (AFMs). Manuals give detailed instructions (procedures and techniques) that tell personnel how to perform their duties. The contents of a manual may be general and deal with principles or doctrines. A manual may direct the step-by-step performance of a specific task. It may include policies or assign responsibilities when these are not covered in another publication. Manuals also differ from regulations in that they contain a foreword page. They have a contents page, which lists chapter titles, main subdivision of chapters, and corresponding page numbers.

Air Force pamphlets (AFPs). Pamphlets usually contain information of a nondirective nature. They are written in an informal style and are usually published in brochure or booklet form. They are permanent in nature, but an expiration clause may be included if it is desired.

Operating instructions. Operating instructions are similar to regulations but they apply only within the issuing headquarters. These instructions are designated "headquarters operating instructions" (HOIs), "branch operating instructions" (BOIs), etc. BOIs must comply with existing higher level directives and be updated accordingly.

Visual aids. Visual aids are charts, posters, or graphic illustrations for indefinite use of display. They are used in connection with planned operations or programs. They do not include posters for temporary display.

Bulletins. Bulletins contain announcements, notices, and temporary instructions. For example, daily or weekly bulletins fall into this category.

Staff digests. These contain summaries of significant staff actions, important announcements, and special notices. They are issued periodically or when needed and at various command levels.

Supplements. Supplements are used by lower headquarters to implement, amplify, interpret, or clarify a higher level publication. A supplement does not alter or change the intent of the basic publication. A lower headquarters cannot supplement the supplement of a higher headquarters, but it can supplement the basic publication. Supplements are filed behind the basic publication, or behind the supplement of the next high headquarters.

Exercises (027):

1. What are the two classes of standard publications?
2. Which standard publication will normally be used to announce policies, assign responsibilities, prescribe procedures, and direct action?
3. What type of standard publication is written in an informal style?
4. Name the type of directives that apply only within the issuing organization.

5. Cite the use made of a supplement.

028. Describe briefly the basic subjects and numbers used to identify standard publications.

Identification of Standard Publications. Because of the large number of Air Force publications, a method for identifying them quickly is needed. The Air Force has, therefore, developed a subject and numbering system to fulfill this need. Basic subjects and basic numbers are assigned to publications.

In the publications numbering system, regulations, manuals, and pamphlets have a double number to simplify reference and control. For example, consider AFR 35-3. The first number (35) is the basic number. It shows the basic subject of the directive to be "Military Personnel." The second number, preceded by a dash (-3), indicates exactly what area of military personnel is covered. In this case, the specific title corresponding to the second number (-3) is "Service Dates." The numbers are assigned by the Director of Administrative Services, Headquarters USAF. With the title, they identify the publication and help you to locate the exact information required.

The basic number is the same for related subjects throughout the different types of publications. For example, AFR 34-4, AFM 34-6, and AFP 34-1-7 are all in the Personnel Services area. Therefore, each has the same basic number of 34. The second number of the AFR, AFM, and AFP tells what part of the personnel services each area covers. Note in the above example that the pamphlet has an additional or third number. The second number provides for grouping under secondary subjects; while the third number is used if a more detailed breakdown is needed. This permits closely related subjects to be issued in separate pamphlets with the same basic and secondary numbers. Let's look at the AFP 50-2 series. Specific identification is given by the third number. Thus, the -26 of AFP 50-2-26 identifies the basic title, Human Relations, for the Air Force Managers; while -27 of AFP 50-2-27 reads Human Relations for Air Force Managers: Seminar Outline 1, Human Relations Basic Concept. The series continues on through AFP 50-2-32. Each pamphlet gives advice on human relations to managers.

Supplements are identified with the basic publications that they supplement and are numbered in sequence (for example, ATC Supplement 1 to AFR 4-1, 18 Jan 73). Remember that every standard publication is given a number and title. This makes it possible to index and file them in an orderly fashion and it makes it simple for you to locate any of them quickly and easily.

Exercises (028):

1. Air Force regulations, manuals, and pamphlets normally begin with a double number. What does the first of these numbers indicate?
2. In the standard publication number AFR 35-4, what does the -4 indicate?
3. What type of standard publication would most likely have a third number?

029. Clarify indexes by specifying the type of information contained in particular indexes and identifying the index used to locate information.

Indexes for Standard Publications. Suppose you want to read about the Battle of Gettysburg. If you should select a book on American history to find the information you need, would you thumb idly through the book until you happened to find what you wanted? No, you would go to the book's index, then turn directly to the indicated pages. From past experience you know that this procedure saves you both time and effort. For the same reason, Air Force standard publications are indexed both numerically and alphabetically. All Air Force publication indexes use the basic number zero (0) as the first digit.

AFR 0-2. This AFR, *Numerical Index of Standard and Recurring Air Force Publications*, lists Air Force regulations, manuals, pamphlets, recurring publications, and visual aids in numerical order by basic series number. After explaining the symbols used and listing the subjects alphabetically with their series numbers, the numerical index is divided into four sections: (1) recurring publications (such as *TIG Briefs*, *Airman* magazine, etc.); (2) visual aids; (3) regulations, manuals, and pamphlets; and (4) obsolete publications (which lists those rescinded or superseded recently). For each current publication listed, the following information is given: number, date, title, the office of primary responsibility (OPR) symbol, and the distribution symbol. A typical entry looks like this:

(No.)	(Date)	(Title)	(OPR)	(Distr.)
R 35-29	9 Nov 70	Support of Dependents	DPMSA	S

Because Air Force publications change frequently, the numerical index is revised and reprinted periodically. When you know the number of a required publication, you should check the index to see whether your organization copy is the current copy with all changes.

For those times when you want to determine the applicable directives but know only the subject, AFR 0-2 does contain an alphabetical listing for this purpose. It provides the basic series number that you should look under to find the specific title and number you want.

Your command and your base issues indexes similar to AFR 0-2. These indexes list directives published at command and local level. If you need information about a certain policy, however, refer first to the current AFR 0-2 to locate the basic publication.

AFR 0-9. This regulation is an index of departmental forms (section A), accountable forms (section B), forms requiring storage safeguards (section C), forms requisitioned quarterly (section D), and obsolete forms (section E).

The section of primary concern to you is departmental forms. This section lists all forms used by the Air Force. These include Air Force (AF) forms, Air Force technical order (AFTO) forms, and Department of Defense (DD) forms, as well as other types of forms. Within each category (for example, "Air Force"), the forms are listed numerically. Other listed information includes the current publication date, the title, and the prescribing directive for each form. The prescribing directive gives detailed information about the form.

The indexes at major command levels and below parallel the same numbering system as we explain above. Indexes, other than 0-2 and 0-9, index the remaining publications in the publications system. In addition to knowing how to locate the standard publications in an index, you must also be able to determine its currency and status.

Exercises (029):

1. What AF publications does AFR 0-2 index or list?
2. You need to determine the series number for the subject "Enlisted Personnel." How should you do this?
3. You need to determine the title of AFR 39-1. How should you do this?
4. You need to know the prescribing directive for AFTO Form 781K, Aerospace Vehicle Inspection, Engine Data, Calendar Inspection, and Delayed Discrepancy Document. What standard publication gives the number of the prescribing directive for this form?

030. Concerning standard publication files, identify the types and determine the currency and status of selected publications in given situations.

Here the topics are publication files and interpreting index entries—sequenced in that order.

Publication Files. To insure that up-to-date information is available, the Air Force prescribes establishment of publications libraries or files. An individual is assigned to keep them current. There are two major types of files. First, there is the master publication library. Such a library is authorized for organizations down to wing or base level—usually no lower. Second, there are the functional publication libraries. These libraries are authorized for lower level activities that need them; however, such files are limited to publications that pertain specifically to the mission of the activity.

Every procedure and policy is subject to change. Changes are necessary whenever new or better equipment or methods are developed. As changes in procedures or policies are introduced, publications covering them are revised, changed, or rescinded. The responsibility for keeping publications current is, first, that of the office of primary responsibility (OPR). From there, it goes down to each individual charged with maintaining the library or file. AFR 5-31, *Publications Libraries and Individual Publications Sets*, prescribes general policies for maintaining current files and indexes.

Interpreting Index Entries. As a publication user, you are not charged with maintaining files. However, you are responsible for checking the currency of the publications you use. The procedure is similar for standard or other than standard publications. First, go to the official file and check the publication date in the proper index.

There are several things you should know about using AFR 0-2. For instance, this index lists regulations, manuals, and pamphlets all intermixed in one section. Since all three publications may have the same number, a letter symbol is used. This letter (R, M, or P) precedes the publication number and thus indicates the type of publication it is.

The file clerk draws a status symbol in the left margin in front of each publication ordered for his file. A red plus sign (+) identifies each publication ordered and on hand (a current copy). A red minus sign (-) indicates that a publication is on order, but a current copy is not on hand. If an index listing is changed in some way from that printed in the current in the current index, the file clerk writes these changes in red in the index.

You may sign out for a loan of a publication from official files on a AF Form 614 (Charge Out Record). The maximum loan period is 3 days. Don't be too eager to get a copy for your own personal use. There may be temporary advantage to this, but before long the publication may be obsolete.

Exercises (030):

1. Name the two types of standard publication files.
2. Publications that are used daily on the job will normally be found in what library?
3. What regulation prescribes policies on maintaining publication files?
4. *Situation:* You are using an AFM with a date of 3 May 73. You want to determine if this manual is current. What could you do to determine this?
5. Looking in the index for AFR 39-62, you notice that some one has placed a red dash (-) in front of the number. What does this tell you?
6. If you checked AFR 34-3 out of the master publications library file on 3 May, on what date should you return it?

3-2. Technical Orders

When you buy a new commercial appliance, car, or some other mechanical device, you receive a book of operating and maintenance instructions from the manufacturer. The manufacturer gives you these instructions so that you can obtain the greatest possible satisfaction from your purchase.

The Air Force, like the manufacturer, provides printed instructions about the operation and maintenance of its equipment. This material is in the form of technical orders (TOs). These TOs give you procedures for inspecting servicing, lubricating, removing, replacing, operationally checking, adjusting, and troubleshooting the equipment you work on.

As its name implies, a TO is a military order and, like any other military order, must be carried out implicitly. Accidents and malfunctions that have occurred on aircraft and ground equipment can often be traced to failure on the part of personnel to strictly observe each and every requirement included in the pertinent TOs. Such negligence not only endangers the lives of others and impairs the accomplishment of our mission but

also represents a grave breach of military discipline.

Simply stated, a technical order is a military order that we follow until it is rescinded or modified by proper authority. Our weapon systems are complicated devices. In view of this fact, it is impossible for any one individual to absorb and retain all of the knowledge required to operate and maintain this equipment. We must therefore depend upon written technical data.

The Air Force TO order system is authorized by and explained in AFR 8-2, *Air Force Technical Order (TO) System*. However, a detailed explanation of the system is covered in the 00-5 series of TOs.

In this section we will cover the types of TO, TO files, How to file TOs, methods of updating TOs and the tech order deficiency report. First, we will look at the TO numbering system.

031. Given typical examples involving the TO numbering system, determine the meaning of the part of a TO number provided in each example.

Technical Order Numbering System. There are over 80,000 TOs of various types in the Air Force system. If you were to look for a particular TO among all these publications, it would take you quite awhile. To simplify the location of certain TOs, the Air Force separated the TOs into six basic types, as shown in figure 3-1. Then, to simplify the location of TOs even further, the Air Force created the TO numbering system. Each TO has a title and a number for identification purposes. TO numbers are made up of three or more parts, with the parts separated by dashes (-). The category will determine the other parts of the number designator. We shall look at several examples in order for you to understand how they are made up.

Technical order indexes. The first part of an index TO number (0) indicates that it is an index type TO. The second part of an index TO number, which is underlined below, means:

- 0-1- Numerical listing
- 0-2- Alphabetical listing

The third part indicates the equipment category (type of equipment). This holds true only for the numerical indexes because there is only one alphabetical index. See figure 3-2 for an example of an index technical order numbers.

Aircraft technical order numbers. Figure 3-3 illustrates the complete breakdown of a representative aircraft TO number, 1C-130B-2-3. This is a number assigned to one of the sectionalized TOs for the C-130B. Notice that it has four parts separated by dashes. Let's consider the meanings of all of the numbers and letters in this TO number.

The first part (1C) consists of a number designator that identifies the TO category plus a letter designator that identifies the type of aircraft. The following is a breakdown of the letter designators for aircraft:

- 1 - Aircraft General.
- 1B - Bomber Air.
- 1C - Cargo Aircraft.
- 1E - Electronic Aircraft.
- 1F - Fighter Aircraft.
- 1H - Helicopter.
- 1L - Observation Aircraft.
- 1P - Patrol Aircraft.
- 1Q - Drone and Target Aircraft.
- 1R - Reconnaissance Aircraft.
- 1S - Anti-Submarine Aircraft.
- 1T - Trainer Aircraft.
- 1U - Utility Aircraft.
- 1W - Weather Aircraft.

The second part (130B) consists of a number designator that identifies the aircraft model, and a letter designator that identifies the aircraft series.

The third part (2) identifies the kind of TO. The following list gives the meaning of the third part of several category 1 TO numbers:

- 01 - List of Applicable Publications.
- 06 - Work Unit Code Manual.
- 1 - Flight Manual.
- 2 - Maintenance Instructions.
- 3 - Structural Repair Instructions.
- 4 - Parts Catalog.
- 5 - Basic Weight Checklist and Loading Data.
- 6 - Inspection Requirements.

In the example above the -2 means maintenance instructions, but what kind of maintenance instructions? Answer: This is specified by the fourth part in the TO numbers, thus, in 1C-130B-2-9 and 1C-130B-2-12, the -9 identifies the kind of maintenance as flight controls, while the -12 specifies landing gear.

A few category 1 TO numbers have five and six parts. The "Preface" to the NI&RT for category 1, TO 0-1-1-1, *General Aircraft Technical Orders*, gives the details of the meanings of the fifth and sixth parts. Letters can also be used in TO numbers.

Letters, such as the following, identify the type of TO.

- CL - Checklist.
- SS - Safety Supplement.
- S - Operational Supplement.
- WC - Workcard.
- WS - Worksheet.

An example of these letters in a TO number would be 1C-130B-2-2CL-3 (Aircraft Jacking).

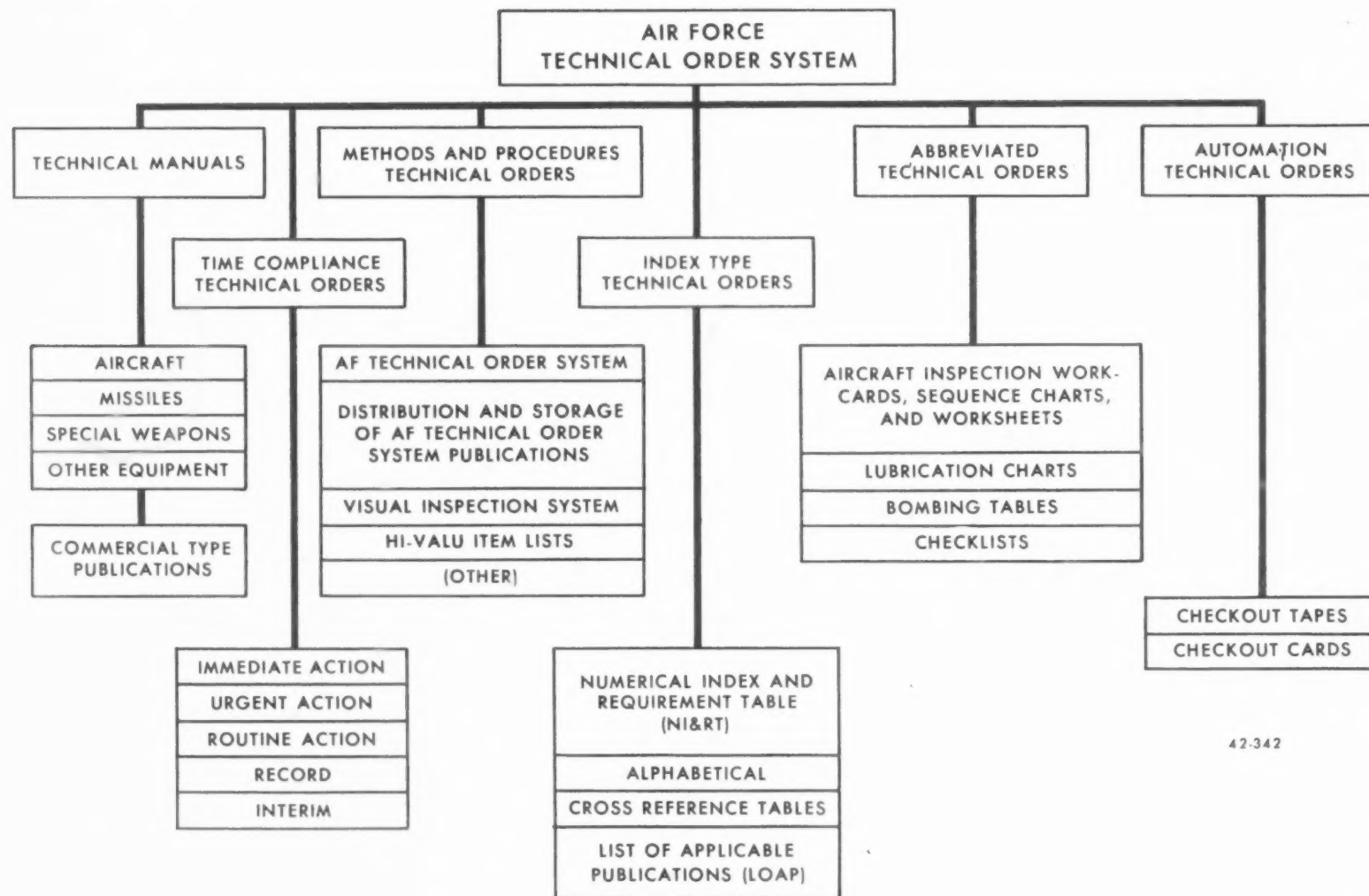


Figure 3-1. Types of technical order publications.

INDEX TECHNICAL ORDERS

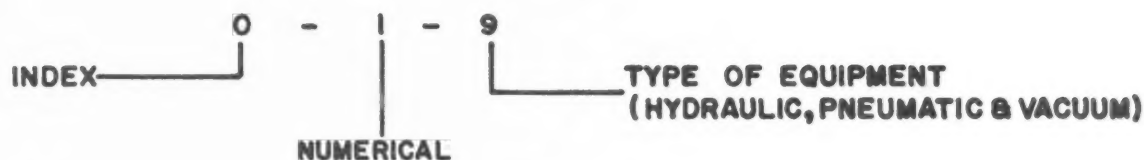


Figure 3-2. Index technical order number.

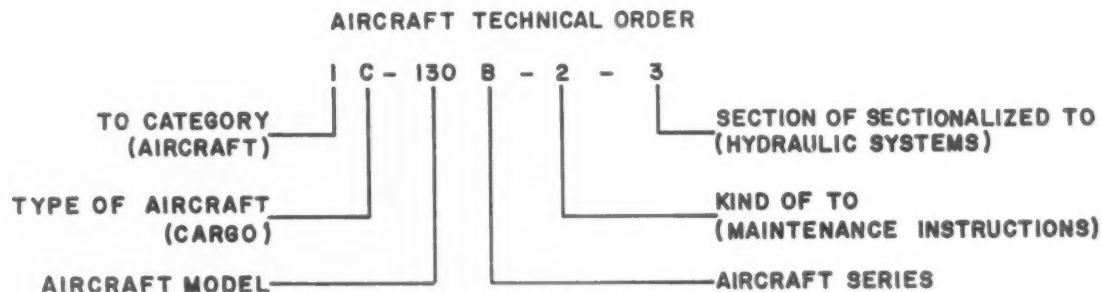


Figure 3-3. Aircraft technical order number.

Equipment or component technical orders numbers. See figure 3-4 regarding these numbers. We will use TO number 9H4-2-41-13 as our example of a four-part component TO number. The first part consists of three designator—the category, the major group, and the specific type of major group. The first designator is the category. The “9” is the category number, indicating that the TO deals with “Hydraulic, Pneumatic or Vacuum.” The Letter “H” identifies the major group, “Hydraulics, Pneumatic or Vacuum.” The Letter “H” identifies the major group, “Hydraulics.” The number (4) following the major group designates the specific type of major group, “pumps.” Thus, the 9H4 indicates that the TO deals with hydraulic pumps. The second part of our number (-2) is known as the specific item number. In this case it is an engine driven type pump. The third part -41 identifies a general series, type, or model of engine-driven pump. The fourth part of the number identifies the kind of TO as follows:

- 1 - Operating instructions.
- 2 - Service or Maintenance instructions.
- 3 - Overhaul instructions.
- 4 - Illustrated parts breakdowns.

If we have a TO number that ends in a 3, we would know that the publications contains overhaul instructions. If the TO number ends in a 4, we

would know that the publications is an illustrated parts breakdown. Our example ends in -13; therefore, it contains overhaul instructions.

Sometimes, due to the simplicity of the equipment, a single TO will incorporate the information of several TOs. As an example, if the overhaul instructions and the illustrated parts breakdown are combined together, the TO will be designated -3 and will be called “Overhaul Instructions with Parts Breakdown.”

Technical manuals may be numbered in increments of 10 to show modifications to the equipment. For example, -3 overhaul instructions could be listed as -13, -23 through -493. The 3 would still signify overhaul instructions, but there has been a change to equipment, such as:

9H4-127-3 O/H with P/B—Solenoid Valve P/N 6024
“C-130B.”
9H8-4-127-13 O/H with P/B—Solenoid Valve P/N 6204-4
“C-130E”

Exercises (031):

1. What number is index 0-1-9 indicates that it is an index?

EQUIPMENT OR COMPONENT TECHNICAL ORDER

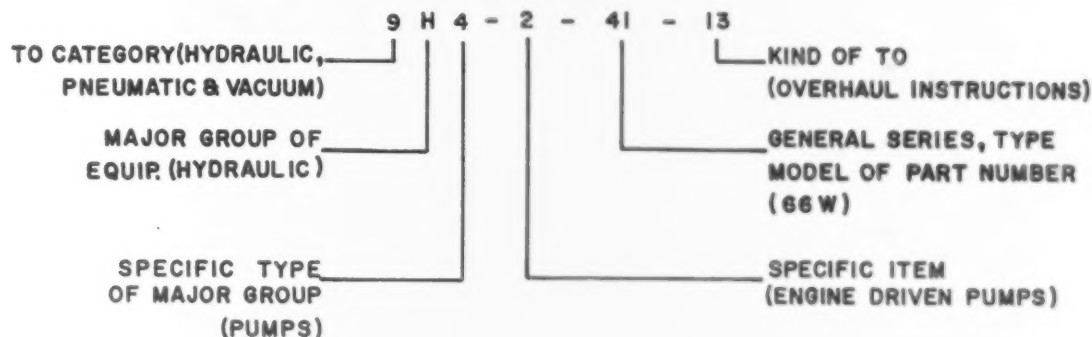


Figure 3-4. Equipment or component technical order number.

2. If the first part of a TO number is 1F, for what type of aircraft does the TO give information?
3. You are looking for an inspection requirements TO. What is the third part of the TO number?
4. In the TO number 1F-4D-2-4, what is the meaning of the designator "4D"?
5. In the TO number 1F-4D-2-4, what is the meaning of the last designator, "4"?
6. Why are technical manuals numbered in increments of 10?

032. Using an extract from an index, list selected requested information that pertains to a specific TO listing.

In this segment we go into NI&RTs as well as the alphabetical index.

Numerical Index and Requirement Table (NI&RT). TOs that list other TOs are called index TOs. One of the most frequently used is the Numerical Index and Requirement Tables

(NI&RT). The NI&RT is a source for locating, by numerical order, TOs that apply to a specific category of equipment. Figure 3-5 shows examples of categories of categories of TO publications. The number of the NI&RT for a specific category can be derived by preceding the category number with 0-1. As an example, figure 3-5 shows that the category for aircraft is "1." The NI&RT that lists aircraft TOs then would be 0-1-1. For landing gear systems, it would be 0-1-4; and for hydraulic, pneumatic and vacuum systems, it would be 0-1-9.

0-1-01 (Indexes and Publications Requirement Tables). The index that lists all NI&RTs is TO 0-1-01, better known as the index of indexes. Refer to figure 3-6 as we discuss each column of the NI&RT. The first column gives the TO number with the security classification beneath it. The indicators are: U—Unclassified, C—Confidential, and S—Secret. The second column shows the title of the publication and more explicit security information. Column 3 gives the printed and change dates. The last column shows the Air Logistics Centers (ALC) with storage and issue responsibility. These listings are explained in the introduction to TO 00-5-2.

NI&RT 0-1-4 (Aircraft Landing Gear Components and Associated Equipment.) Suppose a TO that contains information on the overhaul of a disc type brake is needed. You have the part number (9540918) and the type of aircraft it is used on (C-130A), but don't have the slightest idea where to look first. Well, you know that the brake is part of the landing gear because it is attached to the main gear strut. That's a good place to start; so take the 0-1-01 (fig. 3-6) and look down the page until you come to landing gear and associated equipment. Notice that it is the 0-1-4. Now you

Category

0	Numerical Index and Requirement Tables, Numerical Index, Alphabetical Indexes, and Cross Reference Tables Technical Orders
00	General Technical Orders
1-1	General Aircraft and Missile Technical Orders
1-2	Bomber Aircraft Technical Orders
1-3	Cargo Aircraft Technical Orders
1-4	Fighter Aircraft Technical Orders
1-5	Attack, Anti-Submarine, Helicopter, Observation, Trainer and Utility Aircraft Technical Orders
2	Aircraft and Missile Engine and Associated Equipment Technical Orders
3	Aircraft Propellers and Associated Equipment Technical Orders
4	Aircraft Landing Gear, Components and Associated Equipment Technical Orders
5	Aircraft and Missile Instrument Technical Orders
6	Aircraft and Missile Fuel Systems and Equipment Technical Orders
7	Airborne Engine Lubricating Systems and Associated Equipment Technical Orders
8	Aircraft and Missile Electrical Systems and Associated Equipment Technical Orders
9	Aircraft and Missile Hydraulic, Pneumatic and Vacuum Systems and Equipment Technical Orders
10	Photographic Equipment, Supplies and Sensitized Materials Technical Orders
11	Armament, Fire Control Guidance, Hazard Detecting, Personnel Ejection Seats, and Associated Equipment Technical Orders
12	Airborne Electronic Equipment Technical Orders
13	Aircraft Furnishings, Cargo Loading and Aerial Delivery, and Firefighting Equipment Technical Orders
14	Deceleration Devices, Personal and Survival Equipment Technical Orders
15	Aircraft and Missile Temperature Control, Pressurizing, Air Conditioning, Heating, Ice Eliminating and Oxygen Equipment Technical Orders
16	Airborne Mechanical Equipment Technical Orders
21	Guided Missiles, Probes and Rocket Technical Orders
22	Aerospace Technical Orders
31	Ground Electrical and Electronic Equipment Technical Orders
32	Standard and Special Tools Technical Orders
33	Test Equipment Technical Orders
34	Shop Machinery and Associated Equipment Technical Orders
35	Ground Handling Support, Air and Missile Base Operating Equipment Technical Orders
36	Vehicles, Construction, and Materials Handling and Associated Equipment Technical Orders
37	Fuel, Oil, Propellant Handling and Associated Equipment Technical Orders
38	Nonaeronautical Engines and Components Technical Orders
39	Watercraft and Associated Equipment Technical Orders
40	Commercial Air Conditioning, Heating, Plumbing, Refrigerating, Ventilating and Water Treating Equipment Technical Orders
41	Subsistence and Food Service Equipment Technical Orders
42	Chemical, Oxygen, Metal, Textile, Fuels, Cordage, Lumber and Rubber Materials (Dopes, Cleaning Compounds, Glues, Gases, Lubricants, Paints, Plastics, Etc.) Technical Orders
43	Training Devices, and Associated Equipment Technical Orders
44	Common Hardware Equipment Technical Orders
45	Railroad and Associated Equipment Technical Orders
46	Office, Duplicating, Printing and Binding Equipment Technical Orders
47	Agricultural Equipment Technical Orders
48	Laundry and Dry Cleaning Equipment Technical Orders
49	Optical Instruments, Time Keeping and Navigation Equipment Technical Orders
50	Special Service Equipment Technical Orders

42-345

Figure 3-5. Technical order categories.

will have to go to the 0-1-4. Look in the table of contents, seen in figure 3-7, until you find "brakes." Notice that it refers you to page 1-5. Now turn to page 1-5, figure 3-8. Notice on this page it has one big heading "Brakes." You will have to read each of these entries until you find the correct TO that pertains to the part number of the brake you have. In this case, it is the 8th entry from the top. The TO number is 4B1-2-133; it is overhaul instructions with illustrated parts breakdown. It is unclassified.

It is manufactured by Goodyear for the C-130A Aircraft. Its basic date is 10 Mar 72 and the responsible ALC is 00 (Ogden, Utah).

The **Alphabetical Index**. TO 0-2-1 provides an easy method for locating the correct TO number group when the type of equipment is known. This TO does not give you the TO number, but it does refer you to the proper NI&RT category. Assume that you want the TO number for an "accumulator, cylindrical type, P/N 1356-633498." The

PART I
NEW AND REVISED
PUBLISHED AND UNPUBLISHED
TECHNICAL ORDERS

①	②	③	④
	NUMERICAL INDEX AND REQUIREMENT TABLES		
*** 0-1-01 (U)	NUMERICAL INDEX AND REQUIREMENT TABLES, NUMERICAL INDEX, ALPHABETICAL INDEX, AND CROSS REFERENCE TABLE TECHNICAL ORDERS	25 FEB 77	OC
0-1-02 (U)	GEN TECHNICAL ORDERS	7 OCT 76	OC
*** 0-1-02D (U)	SUPPL -- TITLE SAME AS BASIC	19 JAN 77	OC
0-1-1-1 (U)	GEN ACFT TECHNICAL ORDERS	29 JUL 76	OC
*** 0-1-1-1F	SUPPL -- TITLE SAME AS BASIC	28 JAN 77	OC
*** 0-1-1-2 (U)	BOMBER ACFT TECHNICAL ORDERS	29 JAN 77	OC
*** 0-1-1-3 (U)	CARGO AND SPECIAL ELECTRONIC ACFT TECHNICAL ORDERS	20 JAN 77	OC
0-1-1-4 (U)	FIGHTER ACFT TECHNICAL ORDERS	9 DEC 76	OC
*** 0-1-1-5 (U)	ATTACK, HELICOPTER, OBSERVATION, TRAINER AND UTILITY AIRCRAFT TECHNICAL ORDERS	29 JAN 77	OC
0-1-2-1 (U)	GEN AIRBORNE ENG TECHNICAL ORDERS	25 NOV 76	OC
0-1-2-2 (U)	JET ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	25 NOV 76	OC
*** 0-1-2-2D (U)	SUPPL -- TITLE SAME AS BASIC	26 JAN 77	OC
0-1-2-3 (U)	BOOSTER AND ROCKET ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	25 NOV 76	OC
*** 0-1-2-3C (U)	SUPPL -- TITLE SAME AS BASIC	26 JAN 77	OC
0-1-2-4 (U)	GAS TURBINE ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	25 NOV 76	OC
*** 0-1-2-4D (U)	SUPPL -- TITLE SAME AS BASIC	26 JAN 77	OC
0-1-2-5 (U)	RECIPROCATING ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	25 NOV 76	OC
*** 0-1-2-5D (U)	SUPPL -- TITLE SAME AS BASIC	26 JAN 77	OC
*** 0-1-3 (U)	ACFT PROP AND ASSOCIATED EQUIP TECHNICAL ORDERS	27 JAN 77	OC
*** 0-1-4 (U)	ACFT LANDING GEAR COMPONENTS AND ASSOCIATED EQUIP TECHNICAL ORDERS	27 JAN 77	OC
0-1-5-1 (U)	AIRBORNE INSTRUMENTS TECHNICAL ORDERS	9 OCT 75	OC
0-1-5-1F (U)	SUPPL -- TITLE SAME AS BASIC	8 OCT 76	OC
0-1-5-2 (U)	AUTOMATIC CONTROL SYS, FLT INSTRUMENTS AND ASSOCIATED EQUIP TECHNICAL ORDERS	11 DEC 76	OC
*** 0-1-5-2D (U)	SUPPL -- TITLE SAME AS BASIC	9 FEB 77	OC
0-1-5-3 (U)	ENG AND TEMP, LIQUID LEVEL, QUANTITY AND FLOW MEASURING, ELECTRIC, POSITION AND PRESSURE INSTRUMENT TECHNICAL ORDERS	11 DEC 76	OC
*** 0-1-5-3D	SUPPL -- TITLE SAME AS BASIC	9 FEB 77	OC

Figure 3-6. Numerical Index (0-1-01)

TABLE OF CONTENTS

	Page		Page
Preface	i	4SA1	Shimmy Dampers I-41
PART I		4SA2	Steering Units and Steering
PUBLISHED AND UNPUBLISHED			Dampers I-42
TECHNICAL ORDERS	I-1	4SA3	Valves, Hydraulic Nose Wheel
4			Steering I-45
Aircraft Landing Gear,		4SA6	Brace Assemblies I-47
Components & Associated		4SA7	Pneumatic Valve I-49
Equipment Technical Orders . .	I-1	4SA8	Springs I-49
4A		4SA9	Generators I-49
Landing Gear	I-1	4SA10	Cartridge I-50
4A-1			
Landing Gear--General	I-1	4T	Tires and Tubes, Aircraft . . . I-50
4A1		4T-1	Tires and Tubes, Aircraft--
Float Type	I-1		General I-50
4A2			
Ski Type	I-1	4W	Wheels, Aircraft Landing Gear I-50
4A4		4W-1	Wheels, Aircraft Landing Gear--
Wheel Type	I-1		General I-50
4A5		4W1	Main Wheels I-50
Flotation Type	I-4	4W2	Tail Wheels I-55
4A6		4W3	Nose Wheels I-56
Positioner	I-4	4W4	Wheels Outrigger I-59
		4W5	Helicopter I-59
4AA			
Associated Equipment Landing			
Gear	I-4		
4AA1			
Ski Type	I-4		
4B			
Brake Systems	I-5		
4B-1			
Brake Systems--General	I-5		
4BA			
Associated Equipment, Brake			
System	I-9		
4BA-1			
Associated Equipment, Brake			
System--General	I-9		
4BA1			
Cylinder Brake Actuating . . .	I-9		
4BA2			
Detectors, Skid	I-11		
4BA3			
Reservoirs, Hydraulic Brake .	I-13		
4BA4			
Valves, Hydraulic Brake			
Control	I-13		
4BA5			
Valves, Air Brake	I-19		
4BA6			
Valves, Brake Deboost	I-20		
4BA8			
Controls	I-20		
4BA9			
Control Shields	I-23		
4BA10			
Expansion Chambers	I-23		
4BA11			
Transducers	I-24		
4S			
Struts, Shock Absorbing	I-24		
4S-1			
Struts, Shock Absorbing--			
General	I-24		
4S1			
Struts, Main Landing Gear . . .	I-24		
4S2			
Struts, Nose Landing Gear . . .	I-33		
4S3			
Struts, Tail Landing Gear . . .	I-40		
4S4			
Struts, Outrigger Landing Gear	I-40		
4S5			
Struts, Tail Skid Landing Gear	I-40		
4S6			
Tip Protection Gear	I-41		
4SA			
Associated Equipment, Shock			
Absorbing Strut	I-41		

Figure 3-7. Table of Contents (0-1-4).

BRAKES		DISC TYPE	
		TCO SERIES	
S	4B1-2 (U)		
	4B1-2-43 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 7.50-10 MAIN WHEEL, P/N 9530997 (GOODYEAR) -- L20A -- (REVIEWED AND CURRENT 2 DEC 71)	21 JAN 69 00
	4B1-2-83 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 17.00-20 MAIN WHEEL, P/N 9560819 (GOODYEAR) -- C123K	15 MAY 69 00 CHG 2, 25 MAY 72
	4B1-2-83S-1 (U)	OPR SUPPL -- TITLE SAME AS BASIC	9 JAN 73 00
	4B1-2-93 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 24X7.7 MAIN WHEEL, P/N 9533438, 9530303, 9531386, 9543173 (GOODYEAR) -- T28A, B, C, D	1 AUG 68 00
	4B1-2-93S-1 (U)	OPR SUPPL -- TITLE SAME AS BASIC	25 MAY 71 00
	4B1-2-103 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 6.50-10 MAIN WHEEL, P/N 9520926 (GOODYEAR) -- H19 -- (REVIEWED AND CURRENT 17 NOV 70)	1 DEC 67 00
	4B1-2-133 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 20.00-20 MAIN WHEEL, P/N 9540918, 9550071, 9550402 (GOODYEAR) -- C130A -- (NAVAIR 03-25GAC-7)	10 MAR 72 00 CHG 2, 12 OCT 73
	4B1-2-173 (U)	O/H INSTR WITH IPB -- MULTIPLE DISC BRAKE, P/N 2-727-3 (GOODRICH) -- T38A*YT38	9 JAN 73 00
K	4B1-2-173F (U)	SUPPL -- TITLE SAME AS BASIC (RESC DATE 16 JUL 74)	16 JUL 73 00
	4B1-2-183 (U)	O/H INSTR WITH P/B -- HYD BRAKE FOR 5.00-5 MAIN WHEEL, P/N 9531221 (GOODYEAR) -- H43A, B -- (NOTE REPLACEMENT NOTE IN ERROR. SHOULD READ, THIS PUBLICATION REPLACES T.O. 4B1-2-183 DATED 1 SEPTEMBER 1968.)	14 AUG 72 00
	4B1-2-233 (U)	O/H INSTR WITH P/B -- HYD BRAKE, 17.00-20, MAIN WHEEL, P/N 9560156 (GOODYEAR) -- C123B -- (REVIEWED AND CURRENT 25 MAY 70)	27 JUL 65 00

Figure 3-8. NI&RT 0-1-4.

alphabetical index is like a dictionary; so you would look under accumulator. (Refer to fig. 3-9(A).) Notice that the second item under accumulators says "cylindrical." If you follow the dotted lines across the page, you will come to 9H1-2. This is not the complete TO number, but instead it is the group that the cylindrical accumulators fall under. From the group number you can determine that cylindrical accumulators are in the 9 series category. Placing 0-1 in front of the category number will give you the correct NI&RT to consult. In this example, the correct NI&RT would be 0-1-9.

NI&RT 0-1-9. This NI&RT is divided into two separate sections; Hydraulic Systems (0-1-9-2), and Pneumatic and Vacuum Systems (0-1-9-3). Because our cylindrical accumulator is a hydraulic component, we would look in NI&RT 0-1-9-2. Study figure 3-9(B) here. First, look in the table of contents and find "accumulators, cylindrical," which starts on page I-1. Turning to page I-1 you will find the major heading "accumulators, cylindrical" (see fig. 3-9(C)). The accumulator you are looking for will be found in this section of the TO. You may have to look at each individual line before you find the particular TO that you need. The TO number needed is 9H1-2-55-3, overhaul

instructions with parts breakdown. It is unclassified, manufactured by Harker-Hannifin; its effective date is 15 Aug 71, and its responsible ALC is OC (Oklahoma City). This completes our discussion on TO indexes. Next, we will discuss technical manuals.

Exercises (032):

Refer to figures 3-6, 3-7, and 3-8, as necessary to complete the following exercises.

1. What is the effective date for TO 0-1-1-1?
2. What is the latest change date and the security classification for TO 4B1-2-83?
3. Give the title and responsible ALC for TO 4B1-2-173.

Refer to figure 3-9 as necessary to complete the following exercises.

ACCUMULATORS

Booster, Hydraulic	9H1-5
Cylindrical	9H1-2
Hydraulic, Missile Support	35M21
Hydraulic System	9H1
Missile Support Equipment	35M21
Pneumatic, Missile Support	35M21-3
Pneumatic System	9P14
Pressure, Pneumatic	9P1-3
Propulsion, Missile Support	35M21-4
Spherical	9H1-3
Test Equipment, Associated, Special Purpose	33DA76
Turbo Jet and Turbo-Prop Aircraft and Engine Fuel System	6J25
ACTUATORS	
Aerospace Ground Service Equipment	35R18
Air Refueling System	6A1

A

Preface	Page 1
PART I PUBLISHED AND UNPUBLISHED TECHNICAL ORDERS I-1	
9	General Airborne Hydraulic, Pneumatic & Vacuum System Technical Order I-1
9H	Hydraulic, Pneumatic & Vacuum System Technical Orders I-1
9H-1	Hydraulic Systems & Equipment, General I-1
9H1	Accumulators I-1
9H1-2	Accumulators, Cylindrical I-1
9H1-3	Accumulators, Spherical I-5
9H1-4	Accumulators, Sustainer I-6
9H1-5	Accumulators, Booster I-6
9H2	Cylinders & Actuators I-6
9H2-1	Cylinders & Actuators, General I-6
9H2-2	Cylinders & Locks, Main Landing Gear I-6

B

ACCUMULATOR, CYLINDRICAL, P/N 2660075M1, M3, M4, 2660076M2, M5, M6 (PARKER) - F111A,D,E			
9H1-2-52-2 (U)	INTERMEDIATE MAINT INSTR	13 FEB 70	OC
9H1-2-52-4 (U)	IPB	6 AUG 71	OC
HYD ACCUMULATOR, P/N 9978 (FLINCHBAUGH PRODUCTS) - FB111			
9H1-2-53-2 (U)	INTERMEDIATE MAINT INSTR	24 JUL 70	OC
9H1-2-53-4 (U)	IPB	13 JUN 69	OC
P/N 8421-030			
9H1-2-54-3 (U)	O/H INSTR WITH P/B - HYD ACCUMULATOR P/N 8421-030 (FLINCHBOUGH) - B52*A7D*F105	1 FEB 71	OC
P/N 1356-633498			
9H1-2-55-3 (U)	O/H INSTR WITH P/B - HYD ACCUMULATOR, P/N 1356-633498 (PARKER HANNIFIN) - A7*B52*F4*F105	15 AUG 71	OC
ACCUMULATORS SPHERICAL			
SPHERICAL HYD PRESSURE ACCUMULATORS, (1500 PSI), P/N 401531, -4, 401698 SERIES, 402961 SERIES, 403249 SERIES, 403714, 403715, 407900-2, 411810, 411850 (BENDIX)			
9H1-3-2-3 (U)	O/H INSTR - (REVIEWED AND CURRENT 19 OCT 71)	15 JAN 55 CHG. 1 JAN 69	OC
9H1-3-2-4 (U)	IPB	15 JAN 55	OC

C

Figure 3-9. Using alphabetical listing.

4. What is the TO group number for "accumulators, spherical?"
5. On what page would "accumulators, spherical" be located in the NI&RT table of contents?
6. What is the TO number for the overhaul instructions on an "accumulator, spherical" with the part number 401696?

033. Examining specific types of technical manuals, specify selected requested information found in such manuals.

Technical manuals, first; aircraft technical manuals, second; and equipment or component technical manuals, third, are our concerns here.

Technical Manuals (TMs). Publications in this broad group of the TO system are those that contain detailed information and instructions required for the operation, maintenance, inspection, overhaul, and identification of Air Force equipment. As a pneumatic systems specialist, you will use technical manuals to perform your day-to-day maintenance. A glance through TO 0-1-01 shows that approximately 50 categories could have technical manuals. Some of these are aircraft, and other are equipment or component type publications. Let's examine some of these publications to see how they are used.

Aircraft Technical Manuals. All these TOs will begin with the number 1, which is the category specifically for aircraft. Some of these manuals are:

- 01 - List of Applicable Publications.
- 06 - Work Unit Code Manual.
- 1 - Flight Manual.
- 2 - Organizational Maintenance Instructions.
- 4 - Illustrated Parts Breakdown.
- 6 - Aircraft Scheduled Inspection and Maintenance Requirements.

List of applicable publications manual (-01 TO). This manual lists all the TOs that apply to a specific aircraft. We will go into more detail on this TO later on in this chapter.

Work unit code manual (-06 TO). This manual contains codes used to report maintenance actions under the maintenance data collections system. Study foldout 1 (at the back of the volume) as we proceed.

Flight manual (- TO). The flight manual contains information needed by the flight crew to operate the aircraft. Included in this technical manual is a

description of the aircraft and its systems, normal operating procedures, emergency operating procedures, a description of the auxiliary equipment, operating limitations, flight characteristics, systems operation, crew duties, allweather operation, and performance data. Even though you are a maintenance specialist, you frequently find information in this manual, such as the descriptions of aircraft systems, helpful in understanding how to perform a specific job.

Organizational maintenance instructions manual (-2 TO). This manual contains essential instructions and information required in the organizational maintenance of the aircraft.

On less complex aircraft, the organizational maintenance instructions are in a single (nonsectionalized) manual.

For the more complex aircraft, several sections contain the maintenance instructions. Each section is a separate publication with a separate TO number. Each section contains sufficient instructions to enable a specialist to maintain a particular aircraft system or item of equipment.

Illustrated parts breakdown manual (-4 TO). This manual contains part breakdowns used to identify and requisition parts for the aircraft. Each part breakdown lists the part number, part nomenclature, and other information necessary to provide part's support for the aircraft. Also, included are illustrations of aircraft assemblies and subassemblies that identify the parts in a breakdown.

Aircraft scheduled inspection and maintenance requirements manual (-6 TO). The -6 TO manual contains the requirements to accomplish scheduled maintenance of the aircraft during its entire service life. Also, it establishes special inspection, accessory replacement interval, and functional checkflight requirements. Furthermore, lists—primarily for shop use—repairs that are not authorized at base level.

Equipment or Component Technical Manuals. These manuals pertain to equipment or component categories other than the aircraft (1) category itself. Of the categories listed in TO 0-1-01, you'll find that many technical manuals have been prepared for such items of equipment as: landing gear and associated equipment (4 category), hydraulic and pneumatic systems (9 category), and test equipment (33 category). Equipment technical manuals are usually one of the following four types:

- -1 operating instructions
- -2 maintenance instructions
- -3 overhaul instructions
- -4 illustrated parts breakdown

Operating instructions (-1 TO). Operation technical manuals can be identified by the -1 in the TO number. When a piece of equipment is of a complex nature, normally a -1 will be published.

The -1 includes such information as (1) description and function of major systems and components; (2) special tools required for maintenance; (3) instructions for use, storage, and shipment; (4) periodic inspection, maintenance, and lubrication requirements; and (5) troubleshooting information. In most cases, the information listed above will be incorporated into either a -2 or -3 technical manual.

Maintenance instructions (-2 TO). Maintenance instruction technical manuals are identified by a -2 in the TO number. The -2 for equipment, other than category 1, includes procedures for the removal and installation, testing, and repair of the equipment.

Overhaul instructions (-3 TO). The -3 contains information such as special tools required to overhaul major components, assemblies, or subassemblies; disassembly, cleaning, and inspection instructions; and repair, replacement, and reassembly instructions for overhaul of the equipment.

Illustrated parts breakdown (-4 TO). The -4 is an IPB of the equipment. It shows the component, assembly, and subassembly breakdown. As with aircraft IPBs, equipment IPBs, can be used for identifying, requisitioning, storing, and issuing parts.

Exercises (033):

1. What information can be found in the list of applicable publications manual?
2. In what manual would you find information that describes the aircraft and its system, normal operating procedures, emergency operating procedures, flight characteristics, all-weather operation, and performance data?
3. What type of information will be found in the -3 overhaul instructions?
4. What manual contains the requirement to accomplish scheduled maintenance on the aircraft during its entire service life?

034. Using extracts from the list of applicable publications (LOAP), give specific component part numbers, TO numbers, and selected overhaul instructions in its illustrated parts breakdown.

Our three topics here are the list of applicable publications, its use, and sections of the overhaul and illustrated parts breakdown manual—in that order.

List of Applicable Publications (LOAP). This document provides a listing of all TOs applicable to a specific weapon system. It will enable you to select and become familiar with publications pertinent to that specific aircraft. It also helps personnel determine the contents of limited TO files that may need to be established. For a typical example, we shall trace through the use of the LOAP with the F-4C aircraft.

Use of the LOAP. The final designator of the LOAP TO number is -01. The take one example, will be TO 1F-4C-01. Refer to figure 3-10 as we proceed with this example. Assume that we need a TO giving overhaul instructions for a hydraulic pressure reducing valve, with the part number 1006120-7. First, open the LOAP to the section called "VALVES, HYDRAULIC." Notice that several valves are listed on this page. Since, however, we are specifically looking for a pressure reducing valve, look down the page until you come to Hydraulic Pressure Reducing Valve. To make sure that we have the right pressure reducing valve, check the part number of the valve against the part number listed in the -01. For hydraulic pressure reducing valve P/N 1006120-7, overhaul instructions with parts breakdown, you will find the TO number to be 9H8-15-23-3. Notice the M and the C on the right side of the title. The M stands for manual, while the C is the series right side of the title. The M stands for manual, while the C is the series of the F-4 aircraft. If this valve were used for an F-4D aircraft, then a D would be in this column. When no specific model of aircraft can be determined, the Level of Accomplishment column will either reflect "All" or will be left blank.

The information contained in the technical manual entitled "Overhaul with Parts Breakdown," as well as how it will be used, will be covered next.

Sections of the Overhaul and Illustrated Parts Breakdown Manual. Assume that the hydraulic pressure reducing valve, which we have found previously in the LOAP (1F-4C-01) is leaking and needs to be repaired. To do this task, TO 9H8-15-23-3 must be used. As this TO title suggests, the TO shows two main sections: overhaul instructions and an illustrated parts breakdown. Each section will be discussed separately.

Overhaul instructions (O/H). The information contained in this section is set up in the sequence you would normally follow to repair the component. The list of Leading Particulars provides general information pertaining to hydraulic fluid used, pressure adjustments, operating temperatures, etc. Any special tools needed to overhaul this particular component are also listed. If no special

SECTION I STANDARD TECHNICAL ORDERS

T.O. 1F-4C-01

T.O. NUMBER	TITLE	TYPE	LEVEL OF ACCOMP	T.O. NUMBER	TITLE	TYPE	LEVEL OF ACCOMP
HYDRAULIC SELECTOR VALVES (CONTINUED)				HYDRAULIC SHUT-OFF VALVES			
9HB-14-267-3	2630111-7, 2630111-9, 2630111-11. - OVER(PARKER)			9HB-4-160-3	BUTTERFLY VALVE, P/N'S 626T100-3, 626T100-4, 626T100-5, 626T100-6, 626T100-7, 626T100-8, 626T100-9, 626T100-10, 626T100-11, 626T100-12, 626T100-13, 626T100-14. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (TALLEY)	M	C
9HB-14-291-2	F/M INSTR WITH IPB, EJECT COMMAND SELECTOR VALVE, P/N 122014 (AIRBORNE RESEARCH AND DEVELOPEMENT)	M	ALL	9HB-4-195-3	VALVE, LEADING EDGE FLAP BLC SHUT-OFF P/N 1071T100-19 AND -20. - OVERHAUL WITH PARTS BREAKDOWN (TALLEY)	M	E
9HB-14-292-2	FM INSTR WITH IPB, SOLENOID OPERATED 3- POSITION 4-WAY HYD VALVE, P/N H61G0020, H61G0020M1 (PARKER AIRCRAFT CO)	M	ALL	HYD SHUTTLE VALVES			
9HB-14-293-2	FM INSTR WITH IPB, SOLENOID HYD SELECTOR VALVE, P/N 55300 (HYDRAULIC RESEARCH)	M	ALL	9HB-5-68-2	FM INSTR WITH IPB, NOSE LANDING GEAR DRAG BRACE SHUTTLE VALVE, P/N 12715 (GAR-KENYON INSTR)	M	ALL
9HB-14-294-2	FM INSTR WITH IPB, SOLENOID HYD SELECTOR VALVE, P/N 2630104, 2630104M1 (PARKER ACFT)	M	ALL	HYDRAULIC CHECK VALVES			
9HB-14-296-2	FM INSTR WITH IPB, LEADING EDGE SLAT SOLENOID SELECTOR VALVE, P/N MC12950 (M.C. DIVISION KELSEY HAYES CO)	M	E	9HB-6-10-3	SINGLE AND DOUBLE SWING, CONE, AND METERING TYPES CHECK VALVES. - OVERHAUL INSTRUCTIONS (PARKER)	M	C
HYDRAULIC PRESSURE REDUCING VALVE				9HB-6-10-4	PARTS CATALOG -- FOR T.O. 9HB-6-10-3	M	C
9HB-15-23-3	HYDRAULIC PRESSURE REDUCING AND RELIEF VALVE, P/N'S 1006120-4, 1006120-7, 1006120-9, 1006120-10, 1006120-18. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (BENDIX)	M	C	HYD FLOW EQUALIZER VALVES			
HYD FUSE VALVE				9HB-7-4-13	HYDRAULIC FLOW EQUALIZER (3000 PSI, P/N'S 409370, 409370-0-1, 409370-1-1, 466110. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (BENDIX-PACIFIC)	M	RCDE
9HB-16-36-3	HYDRAULIC FLOW REGULATOR VALVE, P/N'S 32970, 32970-1. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (STERER)	M		9HB-7-8-3	O/H INSTR WITH IPB, LEADING EDGE SLAT FLOW EQUALIZER, P/N 63044 (ABEX CORP)	M	
CONTROL				HYD SEQUENCE VALVES			
9HB-30-32-3	SERVO VALVE, MODEL 50-122A, P/N 010-2400. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (MOOG)	M	C	9HB-9-38-2	FM INSTR WITH IPB, RAM AIR TURBINE HYD SEQUENCE VALVE, P/N 7U7234 (RONSON HYD)	M	ALL
9HB-30-33-3	SPOILER DUAL VALVE, P/N 37400-305, -306. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (BERTEA)	M	C	PNEUMATIC SYSTEMS AND EQUIPMENT			
9HB-30-34-3	SERVO VALVE, P/N'S 75030, 76154. - OVERHAUL INSTRUCTIONS WITH ILLUSTRATED PARTS BREAKDOWN (AMER. BRAKE SHOE CO) (ABEX CORP)	M	RCDE	GENERAL			
9HB-30-81-3	ACTUATOR, LATERAL CONTROL, P/N 110870, 110860. - OVERHAUL INSTRUCTIONS (HYDRAULIC RESEARCH)	M	RC	9P-1-33	PNEUMATIC AND PURGING EQUIPMENT. - OVERHAUL INSTRUCTIONS (KIDDE)	M	A
9HB-30-81-4	IPB -- FOR T.O. 9HB-30-81-3	M	RC	9P-1-34	IPB -- FOR T.O. 9P-1-33		A
PURGE VALVES				PNEUMATIC PRESSURE BOTTLES			
9HB-31-3-3	VALVE ASSEMBLY, P/N 26640478. - OVERHAUL INSTRUCTIONS WITH ILLUSTRATED PARTS BREAKDOWN (VAPOR CORP)	M	E	9P1-2-2-13	AIR BOTTLES AND DRAIN FITTINGS. - OVERHAUL INSTRUCTIONS (KIDDE)	M	A
9HB-34-3-2	FM INSTR WITH IPB, HYD OPERATING VALVE, P/N 46500-9 (HYD RESEARCH)	M	ALL	9P1-2-2-14	IPB -- FOR T.O. 9P1-2-2-13	M	A
9HB-34-4-2	FM INSTR WITH IPB, HYD PRESS OPERATED VALVE P/N 50776-7 (ADEL PREC PRODUCTS)	M	ALL	REGULATORS			
				9P10-4-18-3	FUEL TANK PRESSURE REGULATOR, P/N'S 4-660- 101, 4-660-151. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (SCHULZ)	M	RC
				9P10-4-20-3	PNEUMATIC PRESSURE REDUCER, P/N'S 891584- 0300, 820721. - OVERHAUL INSTRUCTIONS WITH PARTS BREAKDOWN (NADC) (KIDDE)	M	C

CHANGE 3 1-035

Figure 3-10. List of applicable publications (LOAPs).

tools are needed, this will be so stated. In addition, this section will explain the component disassembly procedures. This is the area that will probably cause trouble for most people because it is easy to jump ahead or to skip a step. After the component has been disassembled, each part will have to be cleaned before it can be inspected for defects. The parts found to have defects will have to be repaired or replaced. When all the defective parts have been repaired or replaced, the component must be reassembled. Parts will be lubricated in necessary and reassembled as specified by the TO. At this point, the component is ready to be tested for proper operation. If it fails to operate this failure may mean that the part that has been repaired will have to be replaced. To do this, a part number will be needed and this means that the illustrated parts breakdown must be used.

Illustrated parts breakdown (IPB). The IPB is located in numerical sequence immediately following the overhaul manual. Basically it consists of an exploded illustration of the component and a parts list.

Figures 3-11 and 3-12 are excerpts from TO 9H8-15-23-3. The information part of this section, figure 3-12, contains six columns of data, each of which will be explained in the following paragraphs.

a. Figure and Index No. This column identifies the figure (illustration) and the index numbers of each item in the illustration.

b. Part Number. This is the part number to use if a replacement item must be ordered.

c. Description. This column contains the name of the item. Many times it will contain a complete description of the item, including the code number that identifies the name and address of the company that made the part. You may also be directed to another figure for additional information. Notice that only the first six lines go to the left margin of this column; all other entries are indented one or more spaces, preceded by a dot. The reason for this is to tell you that these parts actually go together to make up the valve assembly.

d. Units Per Assembly. This column lists the number of identical parts that are used on the major assembly. Another entry in this column that you will see is "Ref." This means that the item is entered here only for reference and should not be ordered.

e. Usable On Code. This column tells which unit the part will fit when the TO covers more than one unit, as this does. As an example, six valves are covered by this TO. The one that we want is part number 1006120-7. Follow this line across the page to the Usable On Code column and note that the code for our valve is "C." This means that all the parts coded "C" will be used on valve assembly part number 1006120-7. When no code letter appears, the part is used on all valves.

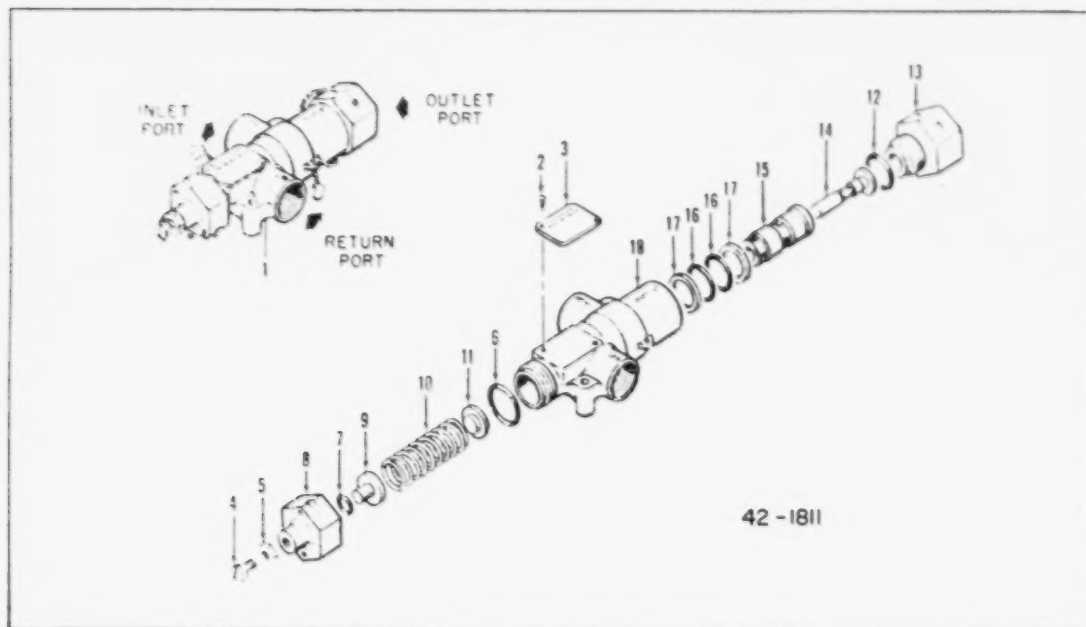


Figure 3-11. Illustrated parts breakdown.

FIG & INDEX NO.	PART NO.	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE	SOURCE CODE
6-1	1006120	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	A	F1
	1006120-4	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	B	F1
	1006120-7	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	C	F1
	1006120-9	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	D	F1
	1006120-10	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	E	F1
	1006120-18	VALVE ASSY, HYDRAULIC PRESSURE REDUCING AND RELIEF.....	1	F	F1
-2	AN535-00-2	. SCREW.....	2		ED
-3	1005985	. NAMEPLATE.....	1		ED
-4	AN500A10-8	. SCREW.....	1	A,B,D,E,F	ED
	AN500A10-10	. SCREW.....	1	C	ED
-5	AN340-10	. NUT.....	1		ED
-6	MS28775-116	. PACKING.....	1		EC
-7	MS28775-010	. PACKING.....	1		EC
-8	L10879-1	. CAP.....	1		P1D
-9	L10881	. RETAINER.....	1		P1D
-10	1006254-1	. SPRING.....	1	A	ED
	554283	. SPRING.....	1	B,E	ED
	1013979	. SPRING.....	1	C,D	ED
	1013952	. SPRING.....	1	F	
-11	L11612	. RETAINER.....	1		ED
-12	1007433-8D	. GASKET.....	1		EC
-13	554422-1	. ADAPTER.....	1	A,B,C,D,E	P1D
	1005932	. ADAPTER.....	1	F	
	547602-1	. SHUTTLE AND SLEEVE ASSY.....	1	A	P1D
	547602	. SHUTTLE AND SLEEVE ASSY.....	1	B,C,D,E	P1D
	1007538	. SHUTTLE AND SLEEVE ASSY.....	1	F	
-14	*547601	. . SHUTTLE.....	1	A,B,C,D,E	X1
	*1007539	. . SHUTTLE.....	1	F	
-15	*547599-1	. . SLEEVE ASSY (Alternate Part No. 1005671-1).....	1	A	X1
	*547599	. . SLEEVE ASSY (Alternate Part No. 1005671).....	1	B,C,D,E	X1
	*1007541	. . SLEEVE ASSY.....	1	F	
-16	MS28775-114	. PACKING.....	2		EC
-17	MS28774-114	. RING, BACKUP.....	2		EC
-18	L11611	. HOUSING.....	1	A,B,C,D,E	X2
	551342	. HOUSING.....	1	F	
**	L62092	. PLUG, SHIPPING.....	3		ED
**	AN6290-5	. GASKET.....	3		ED
6-	1013072-4	. REPAIR PARTS KIT, VALVE. Major Overhaul. For Valve, Part No. 1006120-4 and 1006120-10.	1	B,E	D
6-	1013072	. REPAIR PARTS KIT, VALVE. Major Overhaul. For Valve, Part No. 1006120-7 and 1006120-9..	1	C,D	D
6-	1013072-7	. REPAIR PARTS KIT, VALVE. Major Overhaul. For Valve, Part No. 1006120.....	1	A	D
6-	1011680	. REPAIR PARTS KIT, VALVE. Cure- dated Items. For Valve, Part No. 1006120, 1006120-4 and 1006120-7.....	1	A,B,C	C
6-	1011680-9	. REPAIR PARTS KIT, VALVE. Cure- dated Items. For Valve, Part No. 1006120-9 and 1006120-10.....	1	D,E	C
6-	1011680-13	. REPAIR PARTS KIT, VALVE. Cure- dated Items. For Valve, Part No. 1006120-18.....	1	F	C

*Not procurable as a separate part. Order next higher assembly.
**Used for shipping and storage purposes only.

Figure 3-12. Parts list of IPB.

f. Source Code. Generally the source codes are assigned by Air Force personnel when this equipment is purchased. Assignment of codes is influenced by such things as base facilities, base capabilities, and economic considerations. Definitions of these codes are shown in figure 3-13. For an example of how these codes are used, look at the bottom of the Description column of figure 3-12 and note the six repair kits listed. Find the listing for Repair Parts Kit, Valve Major Overhaul, for valve part number 1006120-7. The kit's part number will be 1013072. Look under the source code for this part and note that it is coded "D." The definition for this code is: "Major

Overhaul Kit. Applied to kits which are available only to maintenance activities authorized to perform depot or major overhaul. These kits do not contain cure-dated parts."

So far we have covered TO indexes and technical manuals. Next we will look at a third type of TO, the time compliance technical order.

Exercises (034):

Refer to figure 3-10, 3-11, 3-12, and 3-13 as necessary to complete the following exercises.

1. What is the TO number of a hydraulic shuttle valve with part number 12715?

APPLICABLE SOURCE CODE DEFINITIONS

- C -- Cure-Dated Components Kit. Applied to kits containing replacement for parts subject to deterioration due to aging or exposure to aromatic fuels, such as rubber gaskets, seals, and "O" rings. C-Kit available to maintenance activities authorized to replace expired cure-dated parts as necessary at overhaul, minor repair, or other times as required by pertinent directives. This kit may include non-cure dated gaskets, packings, etc., as necessary for reassembly after technical order compliance.
- D -- Major Overhaul Kit. Applied to kits which are available only to maintenance activities authorized to perform depot or major overhaul. These kits do not contain cure-dated parts.
- KC - Component of C-Kit; also stocked separately in the appropriate class if followed by the letter "P."
- KD - Component of D-Kit; also stocked separately in the appropriate class if followed by the letter "P."
- P1 - Parts which are very difficult, impractical, or uneconomical to manufacture. Code "P1" parts may be requisitioned and installed by any maintenance level unless followed by the letter "D" (depot), which restricts requisition and replacement to depot level only.
- X1 - Parts for which procurement of the next larger assembly so coded "P1" is justified; e.g. an integral detail part such as a welded segment inseparable from its assembly, a part machined in a matched set, or a part of an assembly which, if required, would suggest extensive reconditioning of each assembly.
- X2 - Parts which are procured through stock, but may be acquired through use of salvage and reclamation. Activities requiring these parts shall attempt to obtain from salvage; if not obtainable from salvage, such parts shall be requisitioned through normal supply channels with supporting justification. Repeated requests shall justify change in code to "P1", if considered economical to procure and stock such parts.

Figure 3-13. Source codes.

2. What type of information is found in the list of Leading Particulars?
3. Where will special tools needed to overhaul the component be found?
4. Look at index 14 of figure 3-12. What do the two dots before the word "shuttle" mean?
5. How many packing, for part number MS28775-114 are used in the pressure reducing and relief valve?
6. What is the usable on code for Valve Assembly, Hydraulic Pressure Reducing and Relief Valve with part number 1006120-18?
7. Give the source code of the "Cap," part number 410879-1, and explain what the code means.

035. Analyze the nature of TCTOs by listing TCTO types and relating their purpose and selected compliance procedures.

Time Compliance Technical Orders (TCTOs). This type of TO concerns work that must be done with a certain time limit. TCTOs provide for modification of Air Force equipment or furnish instructions concerning one-time inspections.

Time compliance TOs are grouped according to their urgency. Notes preceding the text state the degree of the urgency, when the work will be done, and by whom it will be performed. There are three types of authorized TCTOs: immediate action, urgent action, and routine action. Notice that figure 3-14 also shows a record type TCTO. This type of TCTO is not considered one of the authorized types of TCTOs. Since TCTOs of this type are accomplished primarily by contract maintenance, it is very unlikely that you will ever be involved with them. For this reason, we will not talk about this type in this course.

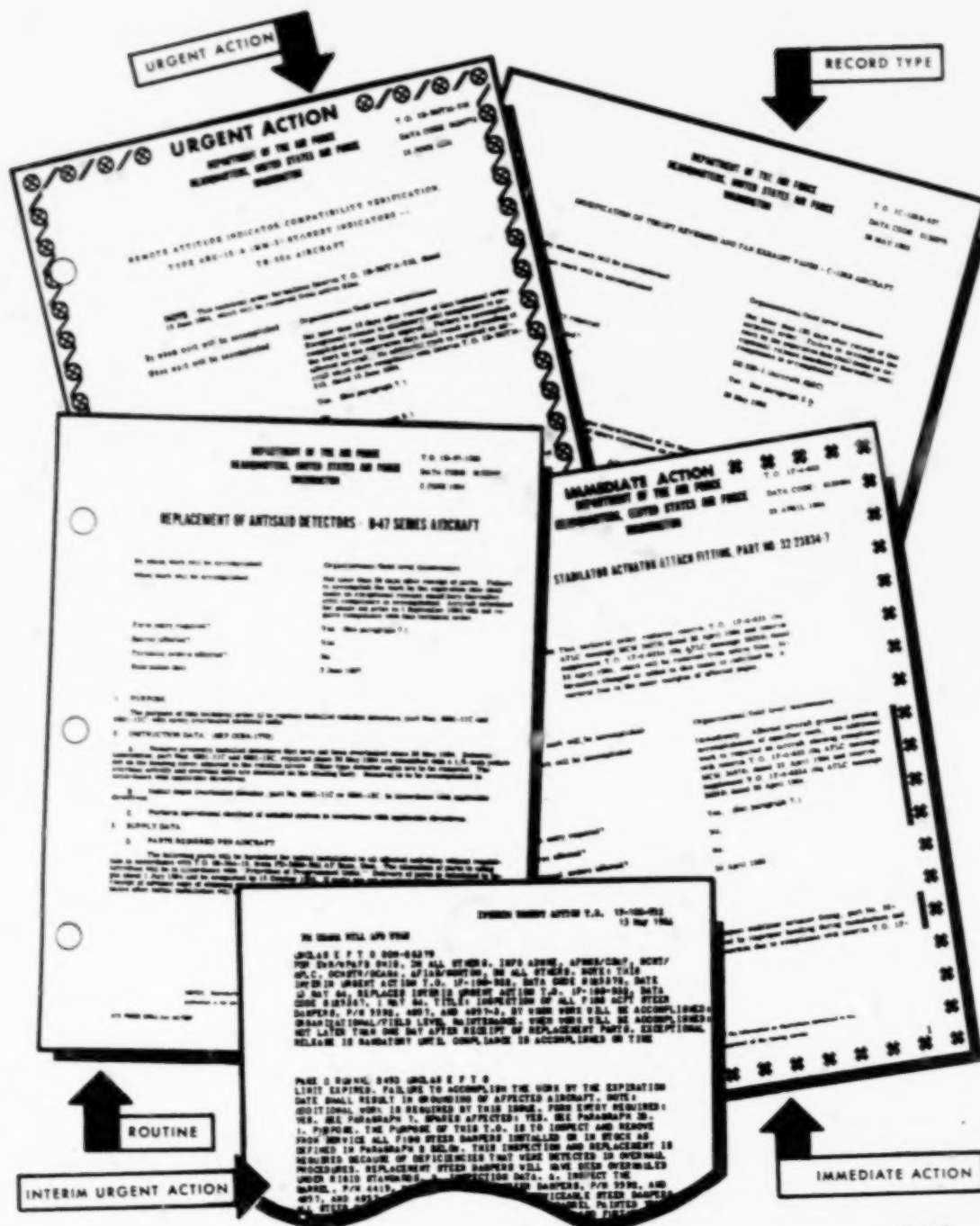
Immediate action TCTOs. Immediate action TCTOs are issued to correct existing unsafe conditions that could result in fatal or serious injury to personnel. They are also issued to prevent possible damage to, or destruction of, valuable

property. These TCTOs require immediate action. They ground aircraft, prevent launch of missiles, and discontinue use of ground or personal equipment. On the top of the first page, the words "IMMEDIATE ACTION" are printed in red. Red Xs are printed around the border of the page. The red Xs provide distinctive identification, and they correspond to the symbol used on maintenance forms. For example, upon receipt of an immediate action TCTO, the equipment is grounded (cannot be used) until the TCTO is completed. Immediate action TCTOs have an automatic rescission (cancellation) date 6 months after their issue date.

Urgent action TCTOs. Urgent action TCTOs take into consideration combat requirements versus any potentially hazardous condition that may exist. These factors might result in injury to people, damage to property, or unacceptable loss of combat efficiency. Such conditions and risks can only be tolerated for a definite time period. At the top of the first page of a TCTO, the words, "URGENT ACTION" are printed in red. A series of red diagonals, alternately spaced with circled red Xs, are printed around the border of the page. Upon receipt of a TCTO, the aircraft involved is placed on a red diagonal during the specified time limit. This time period could be from 1 to 10 days. After this time expires, maintenance forms must be upgraded to a circled red X until compliance. The automatic rescission date for an urgent action TCTO is 12 months after issue.

Routine action TCTOs. These TCTOs contain instructions to remedy defects of equipment or faulty procedures. Failure to comply with this TCTO might reduce the equipment's operational life, affect its operating efficiency, or create a hazard through its prolonged usage. Routine actions TCTOs are printed on plain white paper, without distinguishing red border symbols. These TCTOs are of two types, determined by those who must do the work. Thus, for routine action category I, the work is done by organization/intermediate level maintenance. These TCTOs have a compliance time of 11 to 90 days. After the time limit expires, the aircraft is grounded until compliance is made. Automatic rescission is 12 months after issue date. For routine action category II TCTOs, the work is done by a depot. Such action is scheduled for the next IRAN (inspect and repair as necessary) or overhaul. Exceptional release is not required. The normal automatic rescission date may not exceed 48 months after their issue date.

Interim TCTOs. Interim TCTOs are not a type of TCTO like those we have discussed. Rather, they are issued when the instructions can't wait for formal printing. The issuer uses radiograms, telegrams, teletypes, or airmail to give instructions. This method may be used with immediate action or urgent action TCTOs. Because interim TCTOs



42-343

Figure 3-14. Time compliance technical orders.

constitute a temporary copy, they must be replaced by a formal printed copy within 10 workdays. When an interim TCTO is issued, it is identified thus by: "This is Interim Urgent Action TCTO 1F-4C-501." TCTOs are always numbered -501 and higher for the final designator.

Exercises (035):

1. What symbol is placed on the aircraft forms if an urgent action provided by time compliance technical TCTO is not complied within the specified time?
2. List the three authorized types of TCTOs.
3. When is equipment grounded for an immediate action TCTO?
4. What type of TCTO has a compliance time of 11 to 90 days?

5. What is an interim TCTO?

036. Associate abbreviated, methods and procedures, and automation type TOs with selected information covered in these TOs.

This LO goes into, in order, abbreviated TOs, MPTOs, and automation TOs.

Abbreviated Technical Orders. TOs of this type are primarily work simplification devices. Obviously it would be difficult to carry around bulky technical manuals for instructions on various tasks, such as inspecting or lubricating equipment components parts. For this purpose, inspection workcards, sequence charts, and checklists have been developed in condensed form as abbreviated type TOs to simplify handling.

Inspection workcards. The inspection workcard shown in figure 3-15 outlines minimum inspection requirements. In other words, during an inspection, maintenance personnel should observe both the equipment named in the cards and other components in the surrounding area for obvious defects. The requirements listed in the body of the card are arranged by work areas. They are sequenced in the most logical and practical order of

AFTO FORM 26 JAN 67	AIRCRAFT INSPECTION WORK CARD	CARD NO.	1-112	WORK AREA(S)	6	TYPE MECH RQR	HYD/APG	MECH NO.		CARD TIME	00.40	PUBLICATION NUMBER AND DATE	1T-38A-6WC-3	01 FEB 73
		MAN MINUTES		WORK AREA		WORK UNIT CODE FOR DISCREPANCY		PERIODIC (DOCK)	INSPECTION REQUIREMENTS	ELEC POWER	SERVICE	CARD NO.		
						SYS	SUB-SYS AND COMP			OFF		112		
		010	6	13	14-			1.	FOLLOWING COMPONENTS FOR LEAKAGE (381), CORROSION (170), AND SECURITY (730), HYDRAULIC LINES, AND FITTINGS FOR CHAFING (020), DENTS (780), CUTS (116), LEAKAGE (380), AND SECURITY (730):					
			6	13	14-			A.	GEAR ACTUATING CYLINDER					
			6	13	14-			B.	DOOR ACTUATING CYLINDER					
			6	13	14-			C.	UPLOCK ACTUATOR					
			6	13	14-			D.	DOOR LOCK ACTUATOR					
			6	13	14-			E.	STRUT DOOR FLAP ROTARY ACTUATOR (AF58-1194 THRU AF-59-1606 AIRCRAFT NOT MODIFIED BY TO 1T-38A-					
			6	13	14-			F.	RESTRICTOR VALVE					
	6	13	111			G.	STRUT ASSEMBLY							
	6	13	14-			H.	SIDE BRACE TORQUE ACTUATOR							
005	6	13	123			2.	GEAR UPLOCK MECHANISM FOR DAMAGE AND SECURITY (7							
005	6	13	425			3.	DOOR UPLOCK FOR DAMAGE AND SECURITY							
010	6	13	1--			4.	MAIN GEAR COMPONENTS FOR CORROSION (170), CRACKS (190), WEAR (020), AND SECURITY (730):							
	6	13	111			A.	STRUT ASSEMBLY							
	6	13	112			B.	TRUNNION ASSEMBLY							
	6	13	113			C.	SIDE BRACE ASSEMBLY							
		CARD NO.	1-112	WORK AREA(S)	6	TYPE MECH RQR	HYD/APG	MECH NO.		CARD TIME	00.40	PUBLICATION NUMBER AND DATE	1T-38A-6WC-3	01 FEB 73

Figure 3-15. Inspection workcard.

accomplishment. Cards are also grouped by the type of specialist required and by work area. This arrangement allows the inspections listed on any particular card to be performed by one individual and permits the assignment of the specialist to a certain work area to do a specific job or a series of jobs. To further aid in making work assignments, the inspection workcard numbers may be plotted on a sequence chart to provide the desired work schedule or sequence in which all predictable or routine maintenance can best be done.

Sequence charts. Sequence charts depict a basic planned work schedule. They also serve as a guide in preparing the actual work schedules. These charts provide a visual means of controlling the assignment of work during an inspection and constitute a ready reference for determining the progress of the inspection. As an example, before the pneudraulic specialist can perform an inspection of the hydraulic components, the panels will have to be removed. What then?

Answer: The dock chief figures that it will take the dock personnel 4 hours to pull the panels; so the pneudraulic specialists will be scheduled to begin after the panels have been pulled.

Checklists. Although not used for inspection or scheduling, checklists are employed to perform various maintenance tasks or operations in the most practical sequence. These abbreviated TOs, list TO procedures in a condensed form. For example, if an aircraft has to be taken into the hangar in order to perform an inspection, checklists would be used to defuel, tow the aircraft, and even jack the aircraft, as necessary.

Methods and Procedures Technical Orders (MPTOs). These technical orders establish policies, methods, and procedures of a general nature and do not relate to specific equipment. Thus, the MPTO differs from a technical manual, which deals with specific aircraft, missiles, or other items of equipment. In other words, if the information does not fall into the category of aircraft, missiles, or other pieces of equipment, then more than likely it will be categorized as methods and procedures TO. Two examples are the preventive maintenance program (00-20 series TOs), and the Air Force TO system (00-5-1). Another easy way of determining whether or not a TO is a methods and procedure TO is by consulting the first digits of the technical order number. All methods and procedures TOs start with 00 as the category number. MPTOs are also divided into two classes. One class involves policies, methods, and procedures relating to maintenance management or administration, such as 00-35D-54 (*USAF Materiel Deficiency Reporting and Investigating System*). The other class involves policies, methods, and procedures relating to equipment in general, such as 00-25-223 (*Integrated Pressure Systems and Components*).

Automation Technical Orders. Automation-type technical orders are tapes and cards with TO data

in digital form. They are used to automatically inspect, test, and operate weapon systems, support systems, and equipment, resulting in immediate analysis of performance. Examples are "repetitive use" checkout punched tapes, punched cards, or magnetic tapes.

Each TO contains all of the information needed to do the particular job for which it was written. After all, the mechanic cannot remember all of the procedures and safety factors involved in doing everything contained in his career field. Because of this, the mechanic must read, interpret, and follow the TO as he performs the task entrusted to him.

Exercises (036):

Match each TO given in column A with the related information found in column B by putting each lettered item (column B) in the space before its corresponding numbered item (column A). NOTE: Each item in column B may be used once or more times.

Column A Information	Column B TO Types
— 1. Visual means of controlling the assignment of work during an inspection.	a. Abbreviated TO.
— 2. Minimum requirements for performing an inspection.	b. Methods and procedures TO.
— 3. How to order TOs.	c. Automation TO.
— 3. Inspection workcards, sequence charts, checklists.	
— 5. Prepunched cards for system checkout.	
— 6. Lists TO procedures in a condensed form.	

037. Clarify TO publications files, limited files, and TO filing by identifying selected limited files and the contents of an operational file, and describing briefly the labeling of a TO binder.

In this segment we will discuss TO publication files, types of limited files, and filing TOs.

Technical Order Publications Files. TO files are authorized to provide quick access to TOs required by personnel at all echelons for the most efficient, economical, and safe accomplishment of assigned duties. A file consists of one or more TOs maintained on a continuing basis. It requires receipt of all changes, revisions, and supplements to the TOs contained in the file. A work or study copy issued for one-time use is not a file. All established files will be maintained in accordance with TO 00-5-2 (TO distribution system). The contents of authorized files will be consistent with and limited to the mission requirements of the organization. Therefore, authorized files are designated as "limited" files.

Types of Limited Files. Many types of limited files exist, but the one with which you, as a

pneudraulic specialist, will come in contact more often are listed below.

Operational files. These are files located in operational and maintenance organizations. They will contain only those TOs required to accomplish the operational and maintenance responsibilities of the activity they serve. This would be the file you have in your own shop.

Aircraft file. This file would be located on the aircraft and could consist of only the flight manual (-1) or a complete set of technical orders on the maintenance instructions for that particular aircraft. The contents of this file will depend on the type of aircraft involved.

Transient aircraft files. On bases where it is normal to service or perform maintenance on transient aircraft, one file of TOs is authorized to be established for that specific purpose. The file will usually contain TOs for each type or model of aircraft that would normally be expected to use the

maintenance facilities of that base. This file should be located in the transient aircraft hangar, or as closely as possible to the flight line.

Filing TOs. TOs are placed in binders in the same numerical order in which they are listed in numerical index and requirements tables. Each standard binder contains a slot on its back in which an AFTO Form 32 is placed, as shown in figure 3-16. Note that the AFTO Form 32 in this figure provides one space for a book number and two spaces for publication numbers. The book number (26) is a locally assigned number. In another file, this same book could be numbered 9-4, which indicates that it is the fourth book containing category 9 technical orders. The two spaces for publication numbers are labeled "From and Thru." The number entered under From is the number of the first TO in the book. The number of the last TO contained in that book is entered under Thru. Any TO whose number falls between the first and

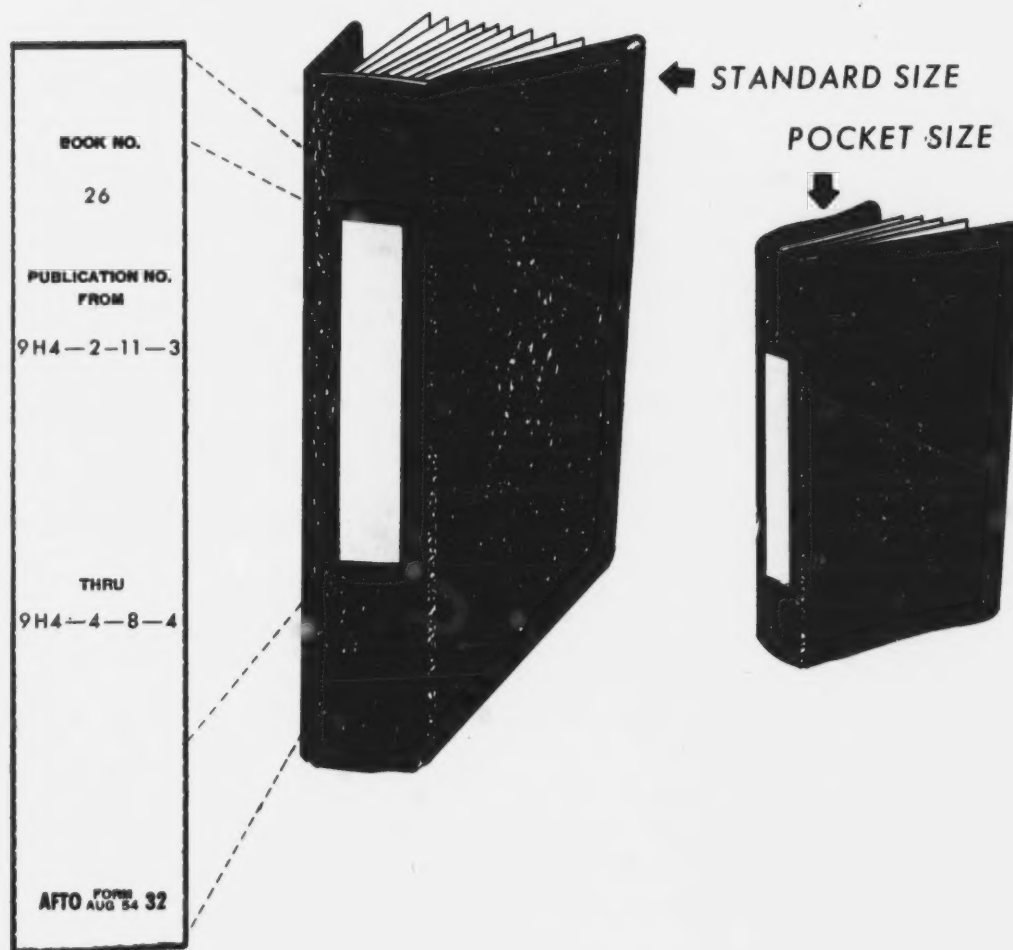


Figure 3-16. AFTO Form 32.

the last TO listed would also be contained in this book. For the pocket size TO binder, you should use a gummed label indicating the contents of the binder.

Exercises (037):

1. What is the AFTO Form number that is placed in the standard size TO binder?
2. In what sequence are TOs placed in binders?
3. If a TO binder label had a book number of 4-2 on it, what would this indicate?
4. List the three types of limited files with which the pneudraulic specialist would come in contact.
5. Describe briefly the contents of an operational file.

038. Examine the methods used to update TOs by specifying these methods and explaining selected ways in which the methods are used.

Methods of Updating TOs. Aircraft can be modified by adding systems or changing parts. Even such a component part as an accumulator can be modified. When this takes place, the information in the TO for that aircraft or part must be changed. This is done through the use of TO revisions, changes, supplements, and rescissions.

Revisions. A revision is a complete new edition of an existing TO. It replaces the original and includes all existing changes. A revision is normally issued when changed pages total 80 percent or more of the basic TO. Revisions are normally made instead of changes when the basic TO consists of eight pages or less. A revision carries a new basic date and is treated as a new TO. When revisions are received, the replacement note on the title page must be checked against the title page to the TO being replaced. If these dates agree, the old TO should be removed and the new replacement TO filed.

Changes. Changes are issued when only parts of existing TOs are affected. The changed pages replace the correspondingly numbered pages. All replaced pages must be removed and discarded.

When changes are received, the complete change must be checked against the new listing on the list of effective pages. This list is on the A page (back of the title page), as shown in figure 3-17. Notice that here it says "On a changed page, the portion of the text affected by the latest change is indicated by a vertical line, or other change symbol, in the outer margin of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas." Notice, also, that this location gives a code key to distinguish the original pages from the change pages and, in addition, gives the total number of pages in the TO. Just below this appear two columns, Title Page No. and # Change No. Look at page 3-4 under the page column; then follow the dotted lines across to the # Change No. column. You can see that these pages are original pages. Page 5 is not an original page because it was replaced by Change 1.

TO page supplement (TOPS). Usually, TOPS are printed on green paper can contain additional material that cannot be fully included on a replacement page. They are normally issued if time and circumstances prevent issuing a standard change. Additional pages are issued and inserted so that they face the affected pages. TOPS changes should include a standard title and A page and should be numbered in the same sequential numerical order as the regular changes. The changed pages must include only the changed paragraph or sentence rather than the entire page. Also, the changed data is placed (filed) next to the page containing the outdated instructions. Inserted pages are given the preceding page number plus capital letter suffixes in consecutive order.

Supplements. Supplements are issued as separate TOs to augment or change data in basic TOs. This is done when the added material may not fit into the basic TO very well.

a. Routine supplements. Routine supplements are identified by the word "supplement" and an alphabetic suffix to the basic publication number. The first supplement normally begins with the suffix letter "C." These are filed to the rear of the basic publication in alphabetical order. The supplement number is then written on the title page of the basic TO. The supplement number can be found on the supplement title page.

b. Safety and operational supplements. Safety supplements are identified by the first (title) page being printed with a border or red SSs and with other important information in red. The words "Safety Supplement" appear at the top and bottom of the title page. The supplement number will contain two S's, as shown in the left illustration of figure 3-18.

The same format applies to operational supplements except that the first (title) page is printed with a border of black OS's, and with the

LIST OF EFFECTIVE PAGES

Insert latest changed pages; dispose of superseded pages in accordance with applicable regulations.

NOTE: On a changed page, the portion of the text affected by the latest change is indicated by a vertical line, or other change symbol, in the outer margin of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.

Dates of issue for original and changed pages:

Original . . . 0 . . 15 Mar 69
TOPS . . Change . . I00 . . 20 Dec 71
Change . . 1 . . 1 Jun 75

Total number of pages in this manual is . 22 . consisting of the following:

Page No.	# Change No.	Page No.	# Change No.	Page No.	# Change No.
Title	1				
A	1				
1-2A	1				
2B Blank	1				
3-4	0				
4A	1				
4B Blank	1				
5	1				
6-12	0				
13-15	1				
16	0				

Figure 3-17. List of effective pages.

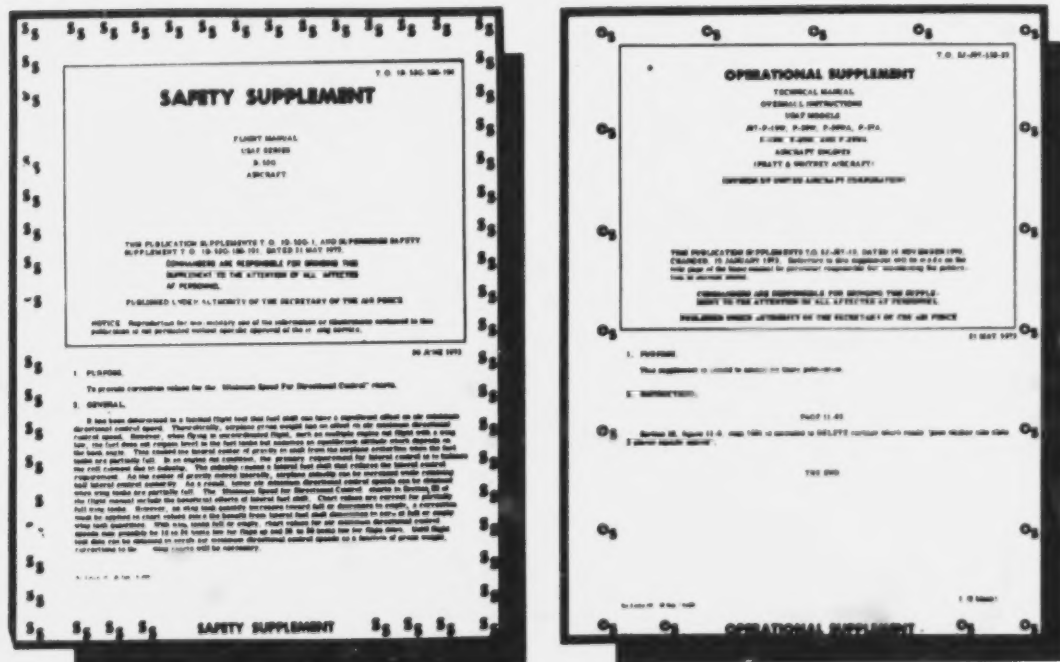


Figure 3-18. Examples of supplement application.

words "Operational Supplement" at the top and bottom of this page, and with all other information appearing in black. The supplement number will contain a single S, as shown in the right illustration of figure 3-18.

Safety and operation supplements are filed in numerical sequence, by date, in front of the basic TO. When safety and operational supplements have the same date, the safety supplement is filed in front. All other supplements are filed in numerical or alphabetical sequence, as applicable, behind the basic TO. Don't forget to make reference to both of these types of supplements on title page of the basic TO.

Rescissions. TOs are rescinded when the information they contain is no longer required. The material may have been incorporated in other publications, or it may no longer be needed. A good example is TCTOs which have automatic rescission dates. Publications will not be removed from the files until listed as rescinded in the NI&RT.

Suppose, while using a TO to disassemble a component part, you find that you cannot follow the procedures as they are outlined in the TO—that an important step was omitted. This TO must be changed, but how can you get the change made? This will be our next area of consideration.

Exercises (038):

1. List the methods used to keep technical orders current and up to date.
2. When will a revision be issued?
3. How are changes to illustrations indicated?
4. Where would you go to find out if a page in a TO is an original or a change?
5. When will a TO page supplement (TOPS) be issued?
6. How are safety and operational supplements filed?

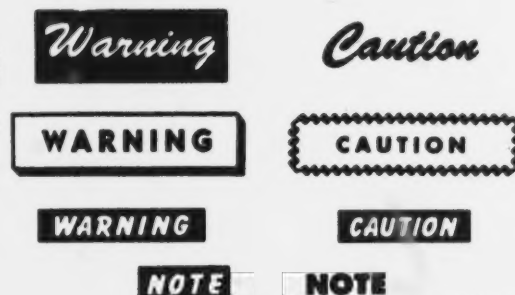
039. Concerning TO terminology and deficiency reporting, specify the use of the terms "Caution," "Warning," and "Note" in TOs and, given a typical situation, determine whether a TO improvement report should be initiated.

First, interpretation of TO information; then TO deficiency reporting are out topics here.

Interpreting TO Information. It is true that interpretation of technical orders is simply a matter of "read and heed," but quite often work is attempted without consulting a technical order. In other instances a mechanic will take a quick glance at the first paragraph, then proceed to tear down a complicated piece of machinery, not realizing that in the second or third paragraph a special piece of equipment might be specified as needed. Don't be so hasty—study the TO from cover to cover, especially if this is the first time you have done this. Pay particular attention to such precautionary words as "Warning," "Caution," and "Note." Not only will these give you valuable information, but also you should know their meaning. Thus, a prefatory "Warning" means that a violation of the procedures that follow could result in injury or death. The word "Caution" entered before procedures means that the equipment involved may be damaged if those procedures are not observed. For all of this, see figure 3-19, which is an excerpt from a section of a TO. Notice that the word "Caution" is set in boldface type, with a border of waving lines. Remember that the word "Note" is used to add emphasis to essential material which follows it.

In addition, examine all of the illustrations and read the Description, Theory of Operation, and Leading Particulars. The reason why this information is so vital to the mechanic is that, if he doesn't know how a particular item operates, he will not know whether or not it is operating properly. In summary, follow every direction given, step by step, not skipping any in order to take shortcuts.

If you find that you cannot follow a particular



43-674

Figure 3-19. Maintenance reminders.

technical order step by step, this fact could indicate an error in it. To correct these errors you would use the TO deficiency reporting system, which we will talk about next.

Technical Order Deficiency Reporting. The term "deficiency" denotes an error or defect that changes the meaning of instructions. It could also give insufficient information to adequately perform a task or function. "Deficiency" does not include minor errors of a nontechnical nature, such as misspelled words, typographical errors, and the improper sequencing of pages. An AFTO Form 22, TO System Publication Improvement Report and Reply, as shown in figure 3-20, is initiated by the person—such as you—who discovers the deficiency. His (your) supervisor will check to insure that the deficiency is valid and important enough for submission. Then, before you submit the report, consult with quality control personnel. They will advise and assist you in preparing this report. From here it goes to the Air Force Logistics Command (AFLC) depot indicated in the Storage and Issue column of NI&RTs. AFTO Forms 22 are submitted

in one of three priorities—emergency, cover letter, or routine.

AFLC takes action on emergency reports within 48 hours after receipt. Cover letter report action is taken within 30 days. Unless routine reports are disapproved, AFLC makes not reply to them. Changes to TOs are published in from 90 to 180 days.

Each of us has the responsibility for reporting any TO deficiency to insure that we have the best up-to-date TOs possible.

This completes our chapter on publications. The next chapter will deal with supply.

Exercises (039):

1. The word "Caution" appears in a TO above a paragraph. Why is this word used?

TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY																																			FORM APPROVED OMB NO. 21-R0207									
1. TO: (Major Command or equivalent) INFO: ATC/LGM Randolph AFB TX 78148										2. TO: (Orgn having Mgmt Responsibility) WARNER ROBINS ALC/MMST Robins AFB GA 31098										3. FROM: (Orgn reporting) HQ SAAS/ATC/MAQ Chamute AFB IL 61868										4. REPORT DATE YR MO DAY 7 5 11 21														
5. BASIC DATE OF T.O. 1 Oct 1964					6. DATE OF T.O. CHANGE 10 July 1975					7. PAGE NUMBER 1-55					8. PARAGRAPH NUMBER					9. FIGURE NUMBER 1-35																								
DOC IDENT		TO		TECHNICAL ORDER NUMBER																									IMPROVEMENT REPORT NUMBER															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
X	Y	A	H		0	0	-	2	5	-	2	2	3																		2	J	H	Q	Q	S	A	A	S	5	1	5	0	R
10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE (Use continuation sheets if necessary) Deficiency: The column for identification of O ring seals (MS28775, MS28778, AN6290 and AN6227) is not current. Reason for change: O ring seals that are received in the field do not have the color coded dots or stripes for identification any longer as stated in 00-25-223. The label on the package has all the necessary information needed for identification. As an example the Military Specification for an AN6227 O ring (Mil-P-55160 dated 5 Jan 1967) stated "O ring packings shall be identified in relation to the manufacture and in conformance to this specification by a proper label on the package." Supply inspectors have assured me that the manufactures of these seals are conforming to the Military Specification as stated above. TO 42E2-1-2 (Identification, use and disposition hydraulic packings and gaskets) dated 1 Nov 1973 does not give any indication that the color coding has been deleted. Does this mean that the color coded dots and stripes have been deleted and if so why? Recommended change: My recommendation is to bring the chart on identification of seals up to date or insert a foot note that these seals are not color coded any longer.																																												
11. REPORTED BY (Initiator's Signature, OAS and Extension) Donald G. Duckworth (TASTC) 2560																				12. APPROVED BY (Supervisor's Signature) M. G. Washington															13. QUALITY CONTROL (Signature) RICHARD L. SHEETZ, WG-12 Deficiency Analyst									

Figure 3-20. AFTO Form 22, Technical Order System Publication Improvement Report.

2. Why is the word "Note" used in the text of TOs?
3. Why must you heed the "Warning" given in the TO?
4. While using a TO, you followed these steps to accomplish a test: step 13 required that external power be disconnected, step 14 required a test set be connected, step 15 directed the application of external power, and step 16 directed the pulling of circuit breakers before power was applied to prevent equipment damage. You believe that an error was made in the step-by-step procedure. Should you submit a deficiency report on this error? Explain.

Supply

THE AIR FORCE has to buy many thousands of items, such as aircraft, vehicles, space parts, maintenance tools, job control consoles, desks, typewriters, etc., at a cost of many billions of dollars each year. This property is stored, issued, and used. Some items are returned for maintenance, which are then repaired, reissued, or shipped off base. This cycle may be repeated several times before an item is no longer usable and is sold for scrap. At this very moment you may be responsible for some of these items.

Although you do not carry an AFSC in the supply field, supply is a big part of your job. As an aircraft preflight mechanic, you must do your part so that maintenance can achieve its mission. Your aerospace vehicles and equipment must be maintained in a serviceable condition, and this cannot be done without supplies. The main objective of the Air Force supply system is to support all activities by providing all necessary supplies and equipment. A secondary objective, and one that is of almost equal importance, is to conduct supply operations in such a way as to conserve all items of material in order to insure that the Air Force receives the maximum possible benefits at the lowest cost. In using ways to conserve, the Air Force is acting in the same way as you when you buy groceries, clothing, etc.—but it and you naturally try to get the most value for your money.

Therefore, regardless of your specific job assignment, you are a key figure in the supply system.

4-1. The Supply System

There is a regular procedure for the requisition, receipt, storage, stock control, issue, shipment, identification, and accounting for supplies by an Air Force organization.

In a sense, supply at the base level is the heart of the supply system. The supplies that a base needs are assembled at base supply for the convenience of the base activities. It is easy to see the inconvenience if the using activities had to deal directly with all of the supply sources used by the Government today. The object of this chapter will

be to familiarize you with what the USAF supply system does for you and how these actions take place.

040. Analyze the supply system by identifying the major command that provides Air Force logistics support and specified responsibilities of the Air Force Logistics Centers.

Maintenance Supply Concept. The Air Force supply distribution system is larger and more complex than any distribution system used in the civilian world. It must procure, stock, and issue nearly 3 million different items to thousands of customers worldwide. Furthermore, the need for speed of delivery and economy of operation—along with the need for immediate response to the diversified and changing needs of its customers—requires more alertness and flexibility than any civilian system.

Since the Air Force supply system is so large and complex, it must be broken down into smaller segments for effective management. Three characteristics of the system are of prime importance in determining the segments. First, the supply system is worldwide. This suggests manageable segments on a geographical basis. Second, accomplishment of the supply mission depends upon the performance of specialized functions, such as storage, distribution, and disposal. This suggests manageable segments on a functional basis. Third, the system contains nearly 3 million items which vary in size, use, complexity, and value. This suggests manageable segments based on a classification system. Actually, all three characteristics are considered in the concept of the supply system. Now we will discuss how supply is broken down to accomplish this tremendous task.

Air Force Logistics Command (AFLC). The Air Force Logistics Command, one of the major commands of the Air Force, operates our supply system under the policy direction of Headquarters USAF. AFLC is responsible for providing worldwide logistics support to the entire Air Force. This includes procurement, storage, and

distribution of supplies as well as the performance of depot level maintenance of materiel. AFLC is made up of a number of Air Logistics Centers that procure supplies from industry and distribute them to air bases throughout the world.

Air Logistics Centers. Air Logistics Centers are organized functionally in that they deal with specific functions of materiel support. They are also organized geographically in that they are responsible for a certain geographical region within the United States. (See fig. 4-1.)

Two very large responsibilities are assigned to ALCs. The first is worldwide management of assigned National Class Codes. For example, consider the NSC of Aircraft Wheels and Brake System; which is 1630. This NSC is taken care of by Oklahoma City Air Logistics Center (OCALC). The second major responsibility is the management depot maintenance of assigned systems. For example, Warner-Robins Air Logistics Center (WRALC) is responsible for depot maintenance on the B-57 and C-54 aircraft.

But, for all practical purposes, the supply system we will primarily be associated with falls under two sections: EMO and SMO.

Equipment Management Office (EMO). EMO is responsible for control of the base equipment management system. So far as your unit is concerned, EMO is the source of supply. It also receives all equipment requests for nonexpendable items listed on the TA for your organization. Examples of these items are tools, machines, and clothing.

Supply Management Office (SMO). This office controls and issues repair parts and maintenance items. These items fall into just two categories: (1) bench stock, which consists of miscellaneous items of expendable hardware and (2) repair cycle items. SMO also issues local purchase items, such as pencils and paper clips.

Exercises (040):

1. What major command provides logistics support for the Air Force?

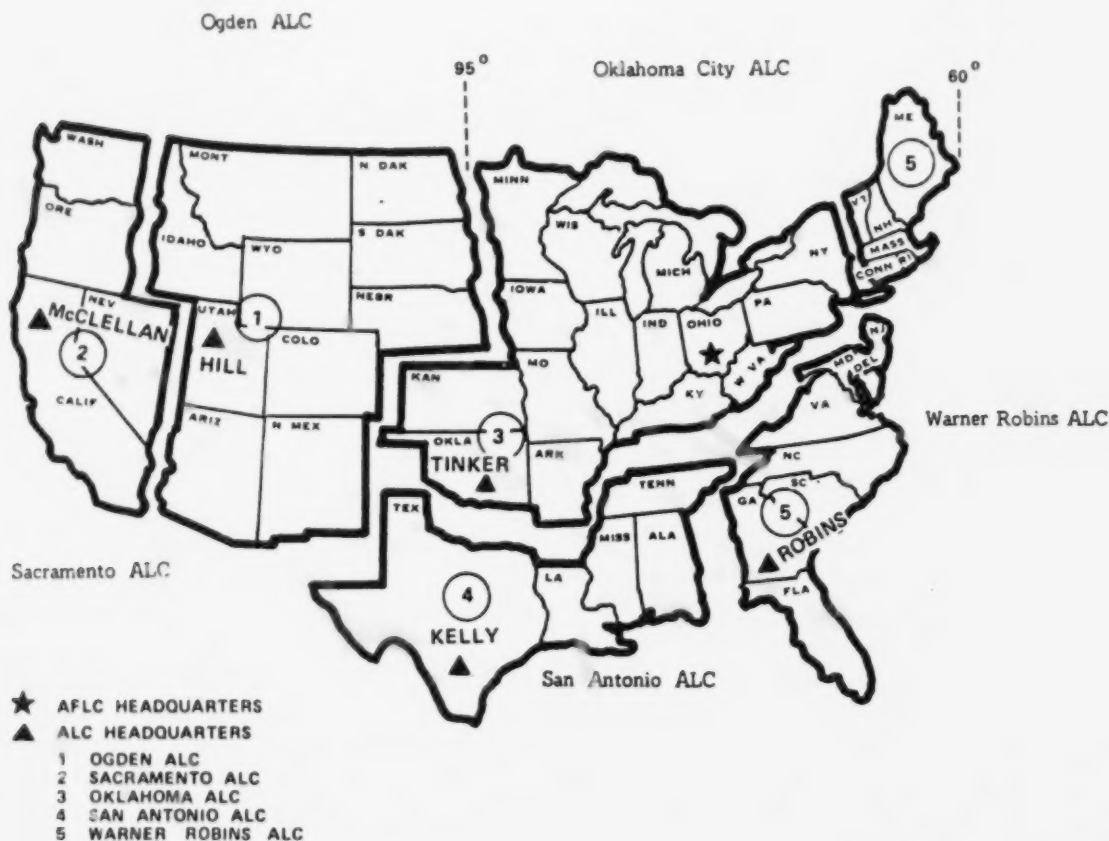


Figure 4-1. Air Logistic Centers.

2. Describe what Air Logistics Centers are.
3. What are the two biggest responsibilities assigned to ALCs?
4. With what two sections of supply would you as a pneudraulic mechanic be associated?

041. Associate selected national stock number terms with related definitions or phrases and distinguish true from false statements about an ERRC designator code.

The national stock number, reference (part) number, and expendability/recoverability/repairability/cost designator codes are—in that sequence—covered in this LO.

National Stock Number (NSN). The national stock number is a 13-digit number which has replaced the 11-digit Federal stock number (FSN). It is used to identify an item in the national supply system. The NSN consists of two distinct portions. The first four digits are the national supply classification (NSC) code, and the next nine digits are an assigned national item identification number (NIIN), as shown in figure 4-2.

National supply classification (NSC) code. The NSC does portion of the NSN is significant in relating the item of supply to other items in the same NSC group/class. Notice that NSC group 47 indicates that it is "pipe, tubing, hose, and fittings." The 30 within the 4730 FSC indicates "fittings."

National item identification number (NIIN). The NIIN is a number of which the first two digits is the national codification bureau (NCB) code, which identifies the country assigning the number. Examples of the (NCB) codes are:

00 - 01—United States
12—Germany
21—Canada
99—United Kingdom

The last seven digits are nonsignificant in that they do not determine the position, sequence, or relation of the item of supply to other items. They serve to symbolize and to fix the identity of the item by numerical means and to identify it from all other items. Remember that the national stock number is used by, not "owned" by, the Air Force. In other words, the NSN is used by other agencies of the Federal Government, such as the Army and Navy.

Reference Number (Part Number). The reference number is used either by itself or in conjunction with other reference numbers to identify an item of production or an item of supply. Reference numbers include manufacturer's drawing, model, type, or source control number. These numbers can

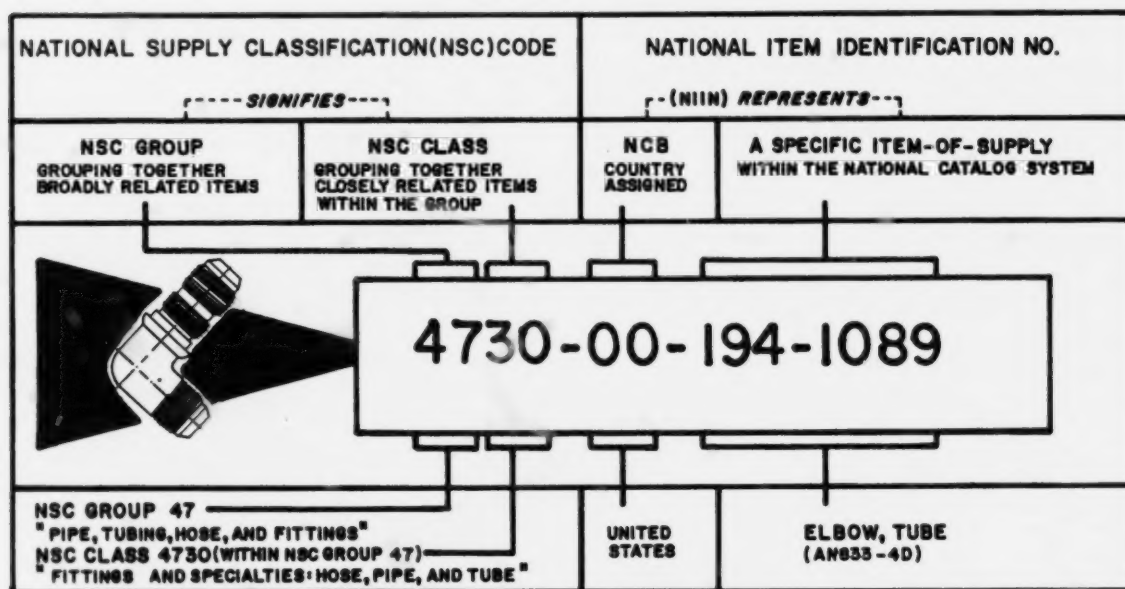


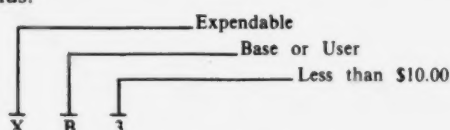
Figure 4-2. National stock number.

usually be converted to NSNs by using the master cross-reference lists (MCRLs).

Expendability/Recoverability/Repairability/Cost Designator Codes. This code will tell you if an item can be placed on bench stock, is a DIFM (due-in-form maintenance), and is used for many other purposes throughout the numerous supply functions. It is difficult to imagine a supply transaction or decision that is not influenced in some manner by the ERRCD codes.

The first position of the ERRCD code identifies the expendability of the item (i.e., X means expendable; N means nonexpendable); the second position identifies the highest authorized repair level (i.e., B means base or user; F means field; D means depot). The third position identifies the cost category (i.e., 1 indicates hi-value items; 2 indicates items of more than \$10.00, but not included on the hi-value lists; 3 indicates items of less than \$10.00).

Thus:



Exercises (041):

- Match each term given in column B with its related definition or phrase in column A, by putting each numbered item (column B) in the space next to its corresponding lettered item (column A). NOTE: Each item in column B may be used once or more than once.

Column A Definitions or Phrases	Column B Terms
— a. Consists of the last nine numbers of the national stock number.	1. National supply classification code.
— b. Relates items of supply by group and class.	2. National item identification number.
— c. Consists of the first four digits of the national stock number.	3. National codification bureau.
— d. Identifies the country assigning the number.	
2. Distinguish true from false statements about an ERRC designator code, writing T for true or F for false beside each of these statements.	
— a. An item coded XF3 can be repaired by depot.	
— b. Hi-value items will be coded XD1.	
— c. Items coded ND2 are expendable.	
— d. XB3 items are repaired by both the field and depot.	
— e. XB2 items are nonexpendable.	

042. Differentiate the correct from the incorrect statements among a series about controlling critical items and the repair cycle asset control system, explaining why the latter are false.

Subjects taken up here are, first, the controlling of critical items and, second, repair cycle asset control.

Controlling of Critical Items. Items designated as critical are normally those items in short supply and for which the demand is excessive. Maintenance supply liaison (MSL) establishes procedures for monitoring the program. It assures the priority handling is afforded to critical items at all times throughout the issue and repair cycle. A critical item monitor is designated within maintenance supply liaison. The critical item monitor insures that maintenance managers and production elements are informed of requirements of the program. Critical item listings are provided to the maintenance shops and to the reparable processing center. The critical item monitor also insures prompt and positive coordination with the base supply critical item monitor in order to keep both production control and supply informed as to the status of critical items in the repair cycle.

The base critical items list is maintained by base supply, in coordination with maintenance supply liaison. This list is periodically checked by both monitors to determine supply and production scheduling priorities. Any item creating two or more NORS (not operationally ready—supply) or cannibalizations in a 30-day period will always be considered for inclusion to the base critical items listing. As the maintenance man, you have several responsibilities to the program. One is to process reparable into repair channels promptly. A reparable item is as important as a serviceable item, since the reparable item may represent the only source of supply. A second responsibility is care in handling and proper packaging. Because these items are critical, they are in short supply on your base or Air Force—wide; therefore, care in handling and packaging them is very important. Your third responsibility is to use proper priority when ordering parts. As an aircraft penudraulic mechanic you are primarily concerned about the particular aircraft on which you are working. When you are ordering parts, at some time in your career, you may be tempted to use a higher priority than your aircraft warrants. DONT.

Repair Cycle Asset Control. The primary objective of the repair asset control system is to bring about the economy of spares procurement through the effective management of assets. A repair cycle asset is an item with the expendability, recoverability, reparability, cost (ERRC) designator code XD or XF.

Repair cycle assets are considered part of the base stock level, whether serviceable or reparable; therefore, positive controls must be established for processing these items. The control of repair cycle assets within intermediate maintenance is accomplished through the operation of a reparable processing center (RPC). The consolidation of the RPC with the repair cycle support unit of base supply will establish a reparable asset control center (RACC).

Now let's see what transpires when a repair cycle asset item is ordered from supply. To begin with, when a demand is made on the supply system, supply researches the information, and if it has the item, it will issue it. Supply then delivers the repair cycle item to the specified location. Next, the individual receiving the item signs and prints his name on the DD Form 1348-1. (The Form 1348-1, Single Line Item Release/Receipt Document, is shown in figure 4-3.) The supply representative will give him copy 2, deliver copies 3 and 4 to RPC or the DIFM monitor, and return copy 1 to the document control section of base supply.

Copy 2 of the issue document is attached to the AFTO Form 350. The reparable item is then sent to RPC for repair. Of course, the production control scheduler schedules the item into the maintenance shop for repair. Then the shop initiates an AFTO Form 349 (Maintenance Data Collection Record) and completes the AFTO Form 350 (Reparable Item Processing Tag) in order to document the action taken and to tag the item when shop action is complete. At this point, the repair cycle asset and its documentation are returned to RPC for turn-in to base supply.

Internal control within maintenance is accomplished through use of the AFTO Form 350. It is initiated by the maintenance specialist removing the reparable item. The supply document number furnished by base supply is entered in block 13 of the AFTO Form 350 by the mechanic completing the form. This number is used to correlate the DIFM document with the AFTO Form 350.

The 1348-1, together with the AFTO Form 350, Part II, provides a means for controlling reparable items as they pass through the reparable process.

The RPC-DIFM monitor will maintain a continuous check of the suspense portion of the DIFM listing daily. This is to insure that reparable items are promptly processed into the repair channel, which will prevent DIFM delinquencies and insure that the location of each DIFM asset is known.

Exercises (042):

Among the following statements, distinguish the true from the false, indicating why the latter are incorrect. Write T for true and F for false in the spaces provided.

- ____ 1. The critical items monitor is part of maintenance supply liaison.
- ____ 2. All items that are not available when needed will be considered critical items.
- ____ 3. One of your responsibilities as a maintenance man to the critical items program is to process reparable items into the repair channels promptly.
- ____ 4. When you order a part for the aircraft you are working on, you should use the highest priority available to get the aircraft back on flying status as quickly as you can.
- ____ 5. The primary objective of the repair cycle asset control system is to provide effective management of those parts to bring about the economy of spare parts procurement.
- ____ 6. A check valve, ERRC designator XB-3, is a repair cycle asset.
- ____ 7. Repair cycle assets are considered part of the base stock level.
- ____ 8. DD Form 1348-1 and AFTO Form 350, Part II, provide a means of controlling reparable items as they pass through the reparable process.
- ____ 9. An actuating cylinder, ERRC designator XF-3, is a repair cycle asset.

043. Using figure 4-4 and from the information/description contained in a list of statements, identify the blocks of the AFTO Form 350.

When an item is removed and replaced, the mechanic fills out an AFTO Form 349

[illegible]

REPLACES DD FORM 1348-1 (UNIVAC), 1 JAN 64 [7 PART]
WHICH WILL BE USED UNTIL EXHAUSTED.

Figure 4-3. DD Form 1348-1.

AFTO FORM 350/MAR 78
PREVIOUS EDITION WILL BE USED

SUPPORT OFFICE
DD FORM 1347

REPAIRABLE ITEM PROCESSING TAG

1. JCS CONTROL NO.	2. IN. / SERIAL NO.	3. IN.	3A. IN. / C.	4. WHEN REQ.
0070003	QA3340	B	ACH	5
5. HOW REQ.	6. ABB	7. WORK UNIT CODE	8. ITEM OPER. / C. / Q. / L.	9. QTY.
381	C-130E	13144	28.0	1
10. INC	11. PART NUMBER			
1650	21962			
12. SERIAL NUMBER	13. SUPPLY DOCUMENT NUMBER			
529	X235HX60020251			
14. DISCREPANCY				
M.L.G. DOOR ACTUATING CYLINDER LEAKING EXTERNALLY AT ROD END				
15. SHOP USE ONLY				
16A. CMD/ACT ID				
SAG NO. 525004 AFTO 350 PL. I				
16. SUPPLY DOCUMENT NUMBER				
X235HX60020251				
17. NOMENCLATURE				
CYLINDER				
18. PART NUMBER				
21962				
19. NEN				
1650-00-621-2251				
20. ACTION TAKEN	21. QTY.	22. RPC USE ONLY		
SAG NO. 525004 AFTO 350 PL. II				

WARNING

Unauthorized persons removing, damaging, or destroying this tag for label may be subject to a fine of not more than \$1,000 or imprisonment for not more than one year or both. (18 USC 1361)

REPAIR CYCLE DATA

23. NEN	24. SRAN CODE			
1650-00-621-2251				
25. TRANSPORTATION CONTROL NUMBER				
STATUS CHANGED TO				
26. SERVICEABLE				
D. Duckworth 02/01/6				
27. CONDEMNED				
28. SUPPLY INSPECTOR'S STAMP				
29. BASE REPAIR CYCLE DATA				
DATE	MO.	DAY	YR.	TIME
REMOVED 02 JAN 76				AWR
REC'D BY RPC				
TO:				
TO:				AWP
TO:				
TO:				
TO:				
TO:				
DATE COMPLETED				

Figure 4-4. AFTO Form 350.

(Maintenance Data Collection Record). When reparable items are involved, an additional form is required for processing the items to and from the shop. This form is the AFTO Form 350.

AFTO Form 350. The AFTO Form 350 (Reparable Item Processing Tag) is a two-part form. The bottom portion of the tag is easily separated along the perforated line. Part I of the 350 (upper portion) is the repair cycle processing tag, and Part II (bottom portion) serves as the production scheduling document. Precise details regarding the use of this form are contained in the 00-20 series technical orders. The completed form serves to identify the origin of the item. Refer to figure 4-4 as we discuss entries required on the AFTO Form 350.

AFTO Form 350 entries (front). Entries for blocks 1 through 14 are completed by the person initiating the form. Most of this information can be taken from the AFTO Form 349 (Maintenance Data Collection Records) that was filled out when the item was removed. Look at these blocks in order.

Block 1 (Job Control Number). The job control number from the AFTO Form 349 is entered in block 1. If a component is broken down into subassemblies, each subassembly is tagged with a separate AFTO Form 350 bearing the original job control number.

Block 2 (ID/Serial No.) Enter the ID/serial number from block 3 of the AFTO Form 349 as applicable.

Block 3. Enter the type maintenance code, TM, in block 3 from column A of the AFTO Form 349 and the three-character equipment classification code (EQ/CL) in block 3A.

Block 4 (When Discovered Code). Enter the applicable when discovered code from column E of the AFTO Form 349.

Block 5 (How Malfunctioned Code). Enter the how malfunctioned code from column F of the AFTO Form 349.

Block 6 (MDS). Enter the mission design/series from block 4 of the AFTO Form 349 if it has been filled in.

Block 7 (Work Unit Code). Enter the applicable work unit code of the item removed. This is the code that had been entered in column C of the AFTO Form 349.

Block 8 (Item Operating Time). If the item is a time change or serially controlled item, enter the calendar time (to the nearest whole month) or accrued operating time (to the nearest whole hour) on the item.

Block 9 (Quantity). Enter the number of like items being forwarded for processing.

Block 10 (FSC). Enter the Federal supply class code (first four digits of the national stock number) for the item being removed.

Block 11 (Part Number). Enter the part number of the item being removed including dashes and slashes. First preference is the manufacturer's part number or complete identification as it appears on the data plate. For items that *do not* have a part number, enter the NIIN including dashes. (NOTE: The NIIN (national item identification number) is the last nine characters of the national stock number.)

Block 12 (Serial No.). For time change and serially controlled items, enter the serial number of the item. If the serial number exceeds 10 positions, enter only the last 10 positions. Serially controlled items and time change items are identified by an asterisk in the work unit code manual.

Block 13 (Supply Document No.). When a demand has been placed on the supply system, enter the supply document number. This code will be given to you when an item is placed on order.

Block 14 (Discrepancy). Enter a brief description of the malfunction. If the part has a warranty, enter the date of installation and date of removal and, also, a statement as to the reason for removal.

Block 15 (Shop Use Only). An entry is not required for on-equipment maintenance. A brief description of the work accomplished on the part is entered in block 15 if the item was made serviceable. If the item is not reparable at your station, enter NRTS (Not Repairable This Station) and the NRTS code.

Block 15A (CMD/ACT ID). Enter the code use in column L of the AFTO Form 349.

Blocks 16 through 18. The information on this lower portion (Part II) is copied from the upper portion (Part I) of the form.

Block 19 (NSN). Enter the national stock number of the item.

Block 20 (Action Taken). Enter the code used in column D of the AFTO Form 350.

Block 21 (Quantity). Enter the number used in block 9 (upper portion).

Block 22 (RPC Use Only). This block used locally, as necessary, by the reparable processing scheduler.

AFTO Form 350 entries (backside). The backside of the AFTO Form 350 contains more spaces, some of which will have to be filled in. Others, however, will be of no interest to you. Refer to figure 4-4 again as we describe the following blocks.

Block 23 (NSN). The national stock number (the same as block 19) is entered here (usually by supply).

Block 24 (SRAN Code). When a component is NRTS, the base stock record account number (SRAN) code is recorded in this block by the shop or RPC.

Block 25 (Transportation Control Number). This block is used by supply only.

Block 26 (Serviceable). This block will be completed by the activity responsible for returning the item to a serviceable status.

Block 27 (Condemned). The activity responsible for determining the condition of an item, will attach to the item either the DD Form 1577 (Unserviceable—Condemned Tag), or the DD Form 1577-1 (Unserviceable—Condemned Label). Instructions pertaining to this action are found in TO 00-20-3.

Block 28 (Supply Inspector's Stamp). This block for supply use only.

Block 29 (Base Repair Cycle Data). The initiator of the AFTO Form 350 fills in the date the item was removed. The production scheduler completes the remaining sections of the block.

Exercises (043):

Place the correct block number alongside each statement that would contain that block's description/information.

- ___ 1. The number of the document that places a demand on the supply system.
- ___ 2. The number of like items being forwarded for processing.
- ___ 3. A three-character equipment classification code.
- ___ 4. Used locally, as necessary, by the reparable processing scheduler.
- ___ 5. The base stock record account number when the components is NRTS.
- ___ 6. A brief description of the work accomplished or the part that made it serviceable.
- ___ 7. The initiator of this form puts the date the item was received in this block.
- ___ 8. A brief description of the part malfunction.

- ___ 9. Completed when the item is found serviceable.

044. Given a list of statements concerning information placed on AF Forms 2005 and 2413, identify the blocks in which that information will be placed.

Quick Reference Lists (QRLs). Included here are frequently used item lists (FUILs). The use of QRLs, better known as quickie lists, at base level is recommended for aircraft units with nine or more aircraft with the same MDS. The QRLs will include only those fast moving, high-usage items required for primary mission aircraft. The purpose of the QRL is to provide maintenance personnel with a speedy identification and communication capability for placing a demand on supply. Additionally, the listings save time for supply by eliminating repetitive research.

AF Form 2005, Issue/Turn-In Request. Before an item can be issued from base supply, demand processing must be supplied with certain information. Most units record this data on the AF Form 2005. This information can be called in by radio or telephone or carried or mailed in. The following is a brief explanation of entries on the AF Form 2005: Refer to figure 4-5 as we proceed discussing this form.

1. ISU (TRIC). Blocks 1, 2, and 3 denote the kind of transaction you are requesting, turn-in (TIN) or issue (ISU). In this case, we want an O-ring seal issued.

TRIC										A. INITIATOR, NAME, DATE (TIN)										B. INSPECTOR, NAME, STAMP, DATE (TIN)									
1 2 3 4 5 6 7										WITKOVSKY 3568																			
ISU 109										REQUESTER, TIME & DATE (ISU)																			
STOCK NUMBER										UNIT OF ISSUE										DOCUMENT NUMBER									
NSC										ADDN										C.									
8 9 10 11 12 13 14 15 16 17 18 19 20										21 22 23 24 25 26 27 28 29										30 31 32 33 34 35 36 37 38 39 40 41 42 43 44									
5330005797916										EABBPPI										X109H560150235R									
D. PART NUMBER, MFR CODE OR NAME/REMARKS										E. T.O. REFERENCE/TECHNICAL PUBLICATION OR END-ITEM APPLICATION/NEAT HIGHER ASSEMBLY																			
MS 28775-115										9H8-2-20-4																			
"O" RING										FIG 2 IND. 14																			
WORK ORDER										SHIP TO										MARK FOR									
45 46 47 48 49 50										51 52 53 54 55 56 57 58 59										60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80									
45 LAB										02																			
F. TIME & DATE OF DELIVERY										G. DELIVERY TIME										H. NOMENCLATURE									

AF FORM 2005 PREVIOUS EDITION WILL BE USED

Figure 4-5. AF Form 2005.

2. Delivery Destination Code, Blocks 4, 5, 6. This is a three-digit code established locally to aid supply in delivering parts.

3. Block 7. When ordering a part you need the name of the requester plus the time and date involved. When turning in a part you need the name of the person who turned in the part plus the date involved (also you can put the applicable telephone number).

4. National Stock Number, Blocks 8 through 22. Usually available on high-use items from QRLs. If the NSN is not available, the part number should be placed in block D, and the technical order references should go in block E. The research section of base supply using this information will convert the part number into an NSN.

5. Unit of Issue, Blocks 23 through 24. This is a term used to define how the material is packaged. Examples: each (EA), gallon (GI), bag (BG).

6. Quantity Required. Blocks 25 through 29. In our case, we asked for one seal. Notice that the other blocks are zeroed out.

7. Activity Code. Block 30 identifies priority-related information. Usually maintenance organizations use the code B for bench stock, R for routine maintenance, or X for expedite.

8. Organization and Shop Code, Blocks 31 through 35. The organization code is locally determined and usually consists of three numbers. The shop codes (blocks 34 and 35) are standardized and are extracted from AFM 67-1, Volume II.

9. Date and Serial Number, Blocks 36 through 43. The dating system used in nearly all supply transactions is the Julian system. The first digit (in block 36) denotes the last digit of the year. The remaining three digits depict the Julian day. Julian days are simply consecutively numbered days starting with 001 for January 1st and ending with 365 for December 31st. The four remaining blocks (40 through 43) are used to tell the number of transactions processed through supply that day.

10. Demand Code, Block 44. The demand code is used by the computer to determine stock levels and repair cycle item control. To the maintenance man these codes usually apply: "R" for a recurring need, "N" for a non-recurring need, or "I" for an initial request.

11. Priority Code, Blocks 60 and 61. The priority, of course, depends upon the urgency.

AF Form 2413, Supply Control Log. The 2413 is used to log the items ordered from supply by your shop. The information usually is called into supply by telephone or by radio. As a requester, you complete the following blanks for demand call-ins. Refer to figure 4-6 as we discuss this form.

1. Delivery destination code (Example: spot 109).
2. Last name, grade.
3. Quick reference list (QRL) number, part number, or stock number.
4. Unit of issue.

5. Quantity required.

6. Noun (not required for QRL call-ins).

7. Job control number.

8. (a) Activity code.

(b) Organization code.

(c) Shop (or flight-line identity) code (Example: HS for hydraulic shop).

(d) Julian date and serial number.

9. Demand code (R—recurring; N—nonrecurring; I—initial).

10. Project code, if applicable.

11. Supply delivery priority.

12. Urgency justification code (Example: BX).

13. End item MDS and serial number or component document number.

14. Technical order, figure, index number (not required for QRL call-in).

15. The time ordered and job control number annotated. To complete the call-in entries, the document number, as provided by supply, will be entered.

16. When the part is received, the time will be placed here. Any remarks, such as back ordered (B/O), received, are entered.

Notice that the codes used on the AF Form 2005, and the codes used on the AF Form 2413 are basically the same. Each organization, depending upon its mission, could use either one or a combination of the two.

Exercises (044):

1. Referring to figure 4-5 for each of the following items, identify the blocks on AF Form 2005 in which the following information will be placed.
 - a. A three-digit code established locally to aid supply in delivering the part.
 - b. The standard shop code taken from AFM 67-1, Volume II.
 - c. The amount of the item you require.
 - d. You are ordering the item to complete bench stock requirements. Where will the code for this activity be placed?
2. Referring to figure 4-6 for each of the following items, identify the blocks on AF Form 2413 in which this information will be placed:

80

- a. Your request is recurring. In what block will the code for this be entered?
- b. The maintenance repair priority designator.
- c. Where the part is to be delivered.
- d. The time the part was ordered and the time and date it was received.

045. Differentiate the correct from the incorrect statements among a series of statements about bench stock establishment and stock issue, explaining why the latter are false.

Bench Stock. Bench stocks consist of working stocks of items assigned ERRC designators of XB2 and XB3 which are repetitive consumption. These designators are the basis for items placed on bench stock. These items would be available in the immediate work area so that uninterrupted operations can continue and the delivery of items to users can be expedited. Random length items, such as hose and tubing and similar items, cannot be included in bench stocks. Random length items are to be requested by the maintenance activity as required; they are stored in the shops in quantities determined by the maintenance supervisors.

The quantity of an item in a bench stock should not exceed 30 days' expected issue requirements. However, this limitation is waived if a special level is approved by supply.

Bench stocks are operated by the bench stock support section in conjunction with the maintenance support activity. The person in charge of the maintenance activity has sole responsibility for providing adequate storage facilities, such as bins and shadow boards, and for establishing local controls which will provide adequate security for sensitive items.

Establishment of a bench stock. The initial establishment of a bench stock is a coordinated effort between the maintenance activity and supply. First, there must be a recurring requirement for a number of expendable items for that maintenance activity. There must be an agreement between supply and the maintenance activity on the location of bench stock and who will use and maintain it. The maintenance activity has the sole responsibility for providing adequate storage facilities and for insuring proper care and conservation of bench stock items. Once established, relocation of bench stocks

must be held to a minimum. The maintenance activity will then submit a recommended list of items to be stocked, along with the quantities needed and full justification, to the bench stock support section. This section reviews the list to determine whether or not past demands justify the items and quantities recommended. Supply approves or disapproves bench stock items and coordinates items disapproved and the reasons for disapproval with the maintenance activity.

Bench stock control. Each item approved for bench stock is assigned a document number by the bench stock support unit. This number is used to identify the items as bench stock and serves as the bin location as well as the document number for all supply transactions. Bench stock support will then make labels to reflect specific information (such as seen in fig. 4-8) for each item on bench stock. Each item on bench stock retains its original assigned item/serial number until deleted, even though the stock number may be changed. Above each bench stock location a wall placard will be installed containing the following information: organization and shop code, date of last inventory, date of next inventory, date of last walk through, and the telephone number of the office to be contacted to resolve immediate bench stock problems.

Issue and replenishment. Mechanics and other users of the bench stock merely help themselves to items as they need them. As a result of the usage, bench stock items must be replenished periodically. Personnel from the bench stock support section physically inventory each bench stock item at least once a month to make sure that an adequate supply of items is on hand at each location. Stock should be replenished when the quantity on hand is under 50 percent of that authorized. If a due-out card is in the bin, this indicates that the part is already on order.

In addition to the monthly inventory, a weekly walk-through inspection will be made by the bench stock support section to determine and replenish out-of-stock items. The maintenance activity is responsible for insuring that a system is devised for flagging out-of-stock items. The flag will tell anyone looking at a glance which bench stock items need to be replenished.

Immediate requirements for out-of-stock items will be submitted to the bench stock support section, which then will take necessary action to replenish the item, if the bin location does not already contain a due-out card. The immediate requirement will be processed just like any other expedite request (fill-or-kill or back order), with an activity code of X instead of B.

Exercises (045):

For each of the following statements, write T for true or F for False in the spaces provided, explaining why the latter are incorrect.

- 1. Bench stock items are consumed rapidly and are placed where they are used.
- 2. The bench stock support section, in conjunction with the maintenance activity, operates the bench stock.
- 3. A mechanic in the shop is singled out by the shop chief and given sole responsibility for bench stock.
- 4. A mechanic must fill out an AFTO Form 601b to get an item from bench stock.
- 5. To establish a bench stock the maintenance activity must submit a list, with quantities and justification, of the items to be stocked to the bench stock support section.
- 6. The labels for each item on bench stock will be made by the maintenance activity where the bench stock bins are located.
- 7. Stock should be replenished when the quantity on hand is 50 percent of that authorized.
- 8. Devising a system for flagging out-of-stock items is the responsibility of the maintenance activity.
- 9. The responsibility of a monthly physical inventory is given to the maintenance activity.
- 10. The initial establishment of bench stock is a coordinated effort between the maintenance activity and supply.

046. Clarify an organization bench stock listing and bench stock label by identifying specific organization bench stock listing entries and information from a selected bench stock label and determining whether the chosen items have cure dated or security codes.

This segment of the test will center on organization bench stock listing, one, and bench stock labels, two.

Organization Bench Stock Listing. An organization bench stock listing is made in order to provide a complete listing of all items authorized in a bench stock. This listing is used by the bench stock support unit as well as by the individual maintenance shops. Bench stock listings differ due to the needs of each maintenance organization. Five different formats for this listing may be selected: a master bench stock listing in either (1) stock number or (2) part number sequence, and an organization bench stock listing in (3) stock number sequence, (4) part number sequence, or (5) item number sequence.

The organization bench stock listing is produced quarterly, following the bench stock review. However, it may be made on an "as required basis at any time.

To help clarify the information on this listing, the following guideline is offered. Use figure 4-7 as you follow along with the explanations given here:

- | | |
|--------------------------|---|
| 1. Card code | This column will have an A for add, D for recommended deletion, and a C for change. All this will be automatically done by the computer. |
| 2. Stock number | National stock number is given here. |
| 3. Part number or | This is self-explanatory. |
| 4. Organization code | A 3-digit code that designates organizations appears here. |
| 5. Shop code | Shop code. Along with organization code; for example, H for hydraulics. Two-digit alpha code. |
| 6. Item number | This is the serial number assigned to the item. Notice that this listing is in bin sequence number. |
| 7. System designator | Type of aircraft or support code appears here. Example: 17 for A7 aircraft and 01 for general support. |
| 8. Nomenclature | The name of the item. This can be tailored to fit your needs, as long as you don't exceed 17 digits. |
| 9. Budget code | This code will tell you whether the item is stock funded or not. Example 1 = system support. 9 = general support. |
| 10. Delivery destination | This is a 3-digit code used by the requester to identify the area of delivery. As the requester, you can use any combination to establish a code. For example: 003 - Bldg P-3, Room E-102, etc. |

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	
CC	STOCK NUMBER	PART/PLIN NR B/S LOCATION	ORG SH	NR	SD	NOMENCLATURE	PRJ	C	DEL	DST	DOLD	DOFD	UI	S	QUANTITY...	UNIT PRICE	EXT AUTH
DI														I	SL	COMP	X
	9150 00223 4134		235 HK	0001	01	HYDRAULIC FL PWR	9	003	5177	4191	GL				20	\$2.55	\$51.50
	9150 00250 0926		235 HK	0002	01	PETROL TECHNICAL	9	003	5150	4193	LB				1	\$.64	\$.64
D	9505 00592 4690		235 HK	0003	01	WIRE STEEL CANNON	9	003	5092	4191	LB				4	\$1.36	\$5.44
C	4730 00842 2202		235 HK	0004	01	ADAPTER MS245087D	9	003	5177	5010	EA				42	\$.89	\$37.38
	5330 00579 8156		235 HK	0005	01	PACKING PREP MS2B	9	003	5150	4191	EA				15	\$.03	\$.45
C	5330 00579 7916		235 HK	0006	01	PACKING PREP AN62	9	003	5177	4191	EA				49	\$.03	\$ 1.47
C	5330 00936 0317		235 HK	0007	01	GASKET MS35803-11	9	003	5177	4191	EA				33	\$.05	\$ 1.65
C	5330 00914 4093		235 HK	0008	01	GASKETPN AN6246/1	9	003	5171	4191	EA				50	\$.10	\$ 5.00
C	5330 00171 8068		235 HK	0009	01	PACKING ANG227815	9	003	5177	4191	EA				28	\$.02	\$.56
	1650 00056 6125		235 HK	0010	01	PARTS KIT CYLINDER	1	003	5171	4191	EA	1	80	22	80	\$2.37	\$189.60
		BC 1			BC 9			BC OTHER			OVERALL						
		L/I AUTH VALUE			L/I AUTH VALUE			L/I AUTH VALUE			L/I AUTH VALUE						
THIS SHOP		1	\$189.60		9	\$103.59		0	\$.00		10	\$293.19					
THIS ORG		1	\$189.60		9	\$103.59		0	\$.00		10	\$293.19					

Figure 4-7. Bench stock listing.

11. Date of last demand (DOLD) This is the date you last ordered this item.
12. Date of first demand (DOFD) This is the date you first ordered this item.
13. Unit of issue Give here the unit issued; for example: each (ea) gallon (GL) pound (LB)
14. Special level Any item on a special level appears here.
15. Authorized level (Qty) Put here the number of items authorized on bench stock.
16. Unit price The price of each item on bench stock is entered here.
17. Total price The price $\times$ number of items you ordered goes here. Example: If you ordered 20 gallons of hydraulic fluid, this would be $20 \times \$2.55 = \$51.00$.

With the explanations, you should now be able to read this listing without much trouble. We don't want you, the average mechanic, to know everything about it, but you should be able to read it. Who knows, you might be placed in charge of the bench stock in your shop!

Bench Stock Label. The bench stock label which is placed on each bin of your bench stock contains quite a bit of information. But have you ever really looked close enough to realize this? If not, review what we have just explained, since each part of the label has been covered as we talked about the bench stock listing—i.e., every part except for the shelf-life and the security codes, which we will discuss next.

Shelf-life code. This code is used to indicate the number of months after the date of manufacture that an item can be used. The date of manufacture may be found on the item package. We will talk about seal packages in Volume 2 of this course. For now, let us say that AFM 67-1 declares that some means of identifying cure-dated items must exist. In the example given in figure 4-8, we have shown two means of identifying whether or not an item is cure dated. Notice the items with an asterisk. First, we have placed a red stripe on the bench stock label. (This is a local policy and may not be used in all

organizations.) This will tell you at a glance whether or not an item is cure dated. Secondly, the bench stock label has a code (5). Look now at figure 4-9. If the code is 5, you can see that it has a shelf life of 60 months, or 5 years. Remember that each item could have a different cure date expiration, however.

Each time an item is taken from a bin, check to see whether or not the shelf-life has expired. Check it against the shelf-life codes found in AFM 67-1. Also, at least quarterly, review items stored in bins with shelf-information codes to see whether or not the shelf life has expired. If you find an item with an expired shelf life. You should remove it or have it removed from the bin, and bring the matter to the attention of the bench stock support section. Note that in some instances, the shelf life can be extended.

Security code. The security code is used to indicate whether a particular item is a controlled item or not. For an example, if you have flashlight batteries on bench stock, you would not want them sitting in an open bin. Why? Because this practice would allow anybody to come in and take the batteries for his own private use. Instead, they should be placed in a controlled area, where they can be locked up. So, if you have a code J, this means a controlled item; whereas if it is coded U, it would not be controlled. Notice in figure 4-8 that the packing is coded U.

Exercises (046):

1. Using figure 4-7, identify the entries for each of the following items on Unit 9505 00592 4690.
 - a. In this item to be added, deleted, or changed?
 - b. The system designator is _____.
 - c. The code that designates the organization is _____.
 - d. The unit of issue for this item is _____.
 - e. The shop is authorized _____.

EXPLANATION OF BIN LABEL FORMAT

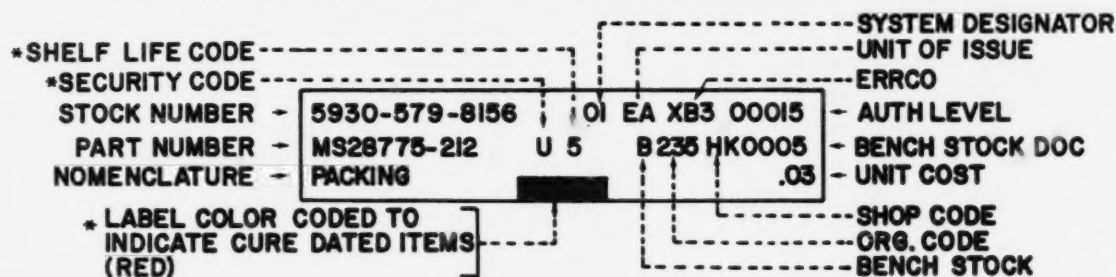


Figure 4-8. Bench stock label.

SHELF LIFE CODES

A 1 Month	1 12 Months	W 33 Months
B 2 Months	M 13 Months	3 36 Months
C 3 Months	N 14 Months	X 42 Months
D 4 Months	P 15 Months	4 48 Months
E 5 Months	Q 16 Months	5 60 Months
F 6 Months	R 17 Months	& 65 Months
G 7 Months	S 18 Months	6 72 Months
H 8 Months	T 21 Months	7 84 Months
J 9 Months	2 24 Months	8 96 Months
K 10 Months	U 27 Months	9 108 Months
L 11 Months	V 30 Months	Z 120 Months
		Y 54 Months

* Shelf Life Code indicates numbers of months item may be used after date of manufacture. Date of manufacture may be found on item package.

Figure 4-9. Shelf-life codes.

2. You are reading a bench stock label and find the security coded J. The J means _____.
3. You have read a number of bench stock bin labels and have noticed the following codes for cure-date expiration. What is the shelf life for each of these codes (see fig. 4-9)?
 - a. B _____
 - b. V _____
 - c. 4 _____
 - d. 6 _____

047. Associate supply condition tags with specified entries to be made on these tags.

The LO discusses the use of supply condition tags and entries on them, in that order.

Use of Supply Condition Tags. There are three supply condition tags that you should recognize. These tags are in the DD Form 1500 series, and each does what its name implies. They identify the condition of the property to which they are attached. They are light cardboard tags or gummed labels for easy attachment to equipment or cartons. Each item condition classification is indicated by a different color tag for easy recognition at a glance. Thus, a yellow tag means the item is serviceable, a green tag tells you that it is repairable, and a red tag indicates that the item is condemned.

DD Form 1574, Serviceable Tag. The yellow (or serviceable) tag, shown in figure 4-10, is used on all new property, on serviceable property, and on

property that has been repaired for turn-in to supply.

DD Form 1577-2, Unserviceable (Reparable) Tag. The reparable, or green tag, is used to identify property that is more economical to repair than to replace.

DD Form 1577, Unserviceable (Condemned) Tag. The red, or condemned tag, figure 4-11, is used to identify property that is worn or damaged beyond economical repair. If this tag is placed on an item, the item must not be used for any reason.

Entries of Supply Condition Tags. The three condition tags are filled out in basically the same way. As we discuss entries on condition tags, refer to figures 4-10 and 4-11.

NSN and description. This block is the same on all three tags and must be filled out accurately. If any question arises about the stock number of nomenclature, call your supply research section.

Serial number/lot number. Here you must enter the serial or lot number from your equipment. This is done to avoid any mixup if the tags accidentally fall off two pieces with the same stock number.

Unit of issue. This entry is self-explanatory and is entered as Ea, Bx, Hd, etc.

Quantity. Self-explanatory, this may be tied together or put in a box with only one tag.

Condition code. The condition code is one of four letters: A, B, F, or H. A means that the property is new while B means that the property has been repaired and is serviceable. A and B are used only on the DD Form 1574, Serviceable Tag. The F is used only on DD Form 1577-2, Unserviceable (Reparable) Tag, and means that the item is repairable. The last code, H, is used only on the red tag, and means that the item is condemned.

DD FORM 1574, 1 OCT 66 GPO : 1967 O-357-603

REPLACES AF FORM 508, WHICH MAY BE USED IN THE USAF.

1650-633-6250
100 8700-4
ACCUMULATOR

SERIAL NUMBER/LOT NUMBER
85972

UNIT OF ISSUE
EA

CONTRACT OR PURCHASE ORDER NO.

QUANTITY

REMARKS

SERVICEABLE TAG-MATERIEL

NEXT INSPECTION DUE/OVERAGE DATE

INSPECTION ACTIVITY
33458M

CONDITION CODE
61868

INSPECTOR'S NAME OR STAMP AND DATE
D. Duckworth
18 JAN 77

YEL

WA 101100 (Unauthorized persons, removing, destroying, or delivering this tag, may be subject to a fine of not more than \$1000 and/or imprisonment for not more than one year or both. (10 USC 1581))

Figure 4-10. DD Form 1574, Serviceable Tag.

Reason. The Reason block is only used on the green and red tags; it explains why the item is in a repairable or condemned condition.

Inspector's name. In most cases the supply or equipment custodian can sign both the serviceable and the repairable tags on all property. A condemned tag can be signed only by a supply inspector for condemned equipment. Normally, items repaired on base can be condemned by a person designated by the Deputy Commander for Maintenance, and they are assigned to the responsible repair facility.

Back of tag. If an item is serviceable but requires correction of minor discrepancies, the delayed discrepancy and supply document numbers, if parts are needed, must be listed on the back of the Serviceable Tag. If the item is unserviceable but you are going to keep it and repair it yourself, the open discrepancy, back-ordered parts, and supply document numbers may be listed on the back of the green tag. Back-of-tag entries will normally apply to shop equipment. Complete instructions for use of condition tags in this manner is contained in TO 34-1-4, *Inspection and Maintenance of Shop Machinery and Equipment*.

Exercise (047):

Match each supply condition tag identified in column B with its corresponding entry to be made on that tag, found in column A, by putting each lettered item (column B) beside its related numbered entry (column A). NOTE: Several items in column B can be used more than once, while others can be used only once.

Column A

Tag Entries

- 1. Signed only by supply inspector.
- 2. Serial or lot number from equipment.
- 3. Condition code of A.
- 4. Reason block.
- 5. Unit of issue.
- 6. Supply or equipment custodian signature.
- 7. Condition code of F.
- 8. Condition code of B.
- 9. National stock number and description.
- 10. Condition code of H.

Column B

Supply Condition Tags

- a. All tags.
- b. Yellow serviceable tag only.
- c. Green repairable tag only.
- d. Red condemned tag only.
- e. Both yellow and green tags.
- f. Both green and red tags.

4-2. Supply Discipline

Money is something with which most of us are concerned. We are all concerned with stretching it out and making ends meet. In this section, we discuss methods of saving money for ourselves and for the Air Force at the same time.

Good business practices are important. Obtaining more supplies than needed to accomplish the mission of your organization is not a good business practice. You normally do not purchase four additional tires as spares for your automobile merely because it has four wheels. Neither is it necessary to buy a spare engine, because the original engine should operate for more than 50,000 miles. These same ideas are followed when you obtain supplies for the Air Force. We call these business practices, the "principles of supply discipline." We want you to know and practice these principles.

FM. PART NO. AND ITEM DESCRIPTION 1650-633-6250 P/N 1008700-4 ACCUMULATOR		UNSERVICEABLE (CONDEMNED) TAG-MATERIEL	
		INSPECTION ACTIVITY 3345 CMS 61868	CONDITION CODE H
SERIAL NUMBER/LOT NUMBER 819		REASON OR AUTHORITY 9H1-2-2-3 Apr. 24	
UNIT OF ISSUE 1st	QUANTITY 1	INSPECTOR'S NAME OR STAMP AND DATE D. Duckworth 8 JAN 77	
REMARKS REF BARRIL EXCESSIVELY WORN			

REPLACES AF FORM 306, WHICH MAY BE USED IN THE USAF.

DD FORM 1577, 1 OCT 66

Figure 4-11. DD Form 1577, Unserviceable (Condemned) Tag.

All personnel working for the Air Force must be responsible for Government property as if it were their own. This applies to officers, airmen, and civilians alike. When you use a piece of Government property, it is like borrowing a book from the library. Sooner or later, you must return it, and you are the one who is responsible for it.

It is important that you clearly understand your responsibility for Government property. Why? Because a time may come when the Air Force will ask you to pay for a piece of equipment. Then, even though your tax money and that of many, many other Americans has already helped purchase this equipment, you may be asked to pay for it again—and you won't even get to keep the property. At such a time, your knowledge of the rules and procedures may relieve you from monetary responsibilities for this equipment's damage or loss.

048. Given a group of statements concerning Air Force property responsibility, differentiate those correct from those incorrect, indicating why the latter are false.

Responsibility for Public Property. The property you must use in your duties, whether it is a desk, a toolbox, a truck, or an electronic test stand, is your responsibility. Good management dictates that the person who is using the property be responsible for its care. Everyone in the Air Force is responsible for some type of property. For one man, it may be a shop full of equipment; for another, a bed blanket. In any case, property responsibility is a part of any position in the Air Force.

Because the Air Force is large and complex, it is necessary to assign responsibility for property. Otherwise, we can never be sure that the property will be adequately safeguarded. This would cause the whole system to fall into wastefulness and carelessness. Let's first determine where responsibility originates.

The money used to buy property comes from all of us in the form of taxes. Therefore, the title to this property is not held by any one individual; it is jointly owned by all of us. We have no problem finding who is responsible for a personal item. We know that if our personal property is abused, we will have to pay for its repair or replacement. But, who is to be responsible for the millions of Air Force items costing billions of dollars? Congress has the responsibility of appropriating the money to buy this property; Congress also passed the law to hold individuals responsible for public property.

Congress passed such a Federal law in March 1894. This law is the authority for regulations concerning responsibility for public property. The Air Force explains the application of this law in AFR 67-10, *Responsibilities for Public Property in Possession of the Air Force*. Certain officers, airmen, and civilian employees are designated as supervisors. Possibly you are one of them or will be in the near future. As a supervisor, you are responsible for carrying out the orders and directives of the commander. As a representative of the commander, you have certain responsibilities for subordinates and property. However, if you are supervising several workers, you cannot be looking over the shoulder of each worker at all times. Therefore, like the commander, as the supervisor,

you cannot be solely responsible for the property in your activity.

In your duty section, you, your supervisor, and your commander have the responsibility for property you are using. If this property should be damaged, the circumstances will determine who is responsible for the damages.

Property responsibility is imposed by law on all officers, airmen, and civilian employees and cannot be delegated, only shared. This responsibility is the obligation of an individual. This is so regardless of duty assignment or level of command or supervision. Depending upon the circumstances, any person, military or civilian, may be charged with one or more of three types of responsibility: command, supervisory, and custodial.

Command responsibility. Each commander at any level has command responsibility for all property under his jurisdiction.

A commander must insure that records of supply transactions are accurately kept. To fulfill this duty, he must rely upon the capabilities of the people in his command. They must know the records to be maintained and the procedures for their accomplishment. It would be almost impossible for the commander to know all of the minute details required for recordkeeping. He must see that the people filling these positions are trained and are trustworthy. To insure economical use, the commander must set an example for those under his command. He must see that supplies are used for their intended purposes and are not wasted. Some examples of waste would be using the firetruck for taxi service or even the waste of the standard paper clip. Numerous other items may be used for purposes other than that for which they were intended. The examples just given only begin the list.

The commander, or his representative, must make frequent visits to the base activities. Thus, he is assured that the property is receiving proper care and is being properly safeguarded. Although AFR 67-10 states that those visits be made often, the time intervals are not stated. The needs of the operation will determine the intervals of the visits. When the activity is operating smoothly, the visits will not need to be made as frequently.

To discharge his property responsibilities, the commander must issue instructions and directives. These should be timely enough to take care of any changes in the mission of his command. They should be issued as required to insure that property is used for its intended purpose and to complete the mission.

Supervisory responsibility. Normally, the supervisor is located near the property for which he is responsible. Although he may not have as many responsibilities as the commander, he has more direct control over the property. Supervisory responsibility applies to any person who exercises

supervision over the property. The property may be received, in use, in transit, in storage, or undergoing modification or repair. It covers the property from the time the Air Force buys it until it is consumed or sold. AFR 67-10 also tells about supervisory responsibilities as it applies to public property.

In situations where the commander has personnel working directly under his supervision, he has supervisory as well as command responsibilities.

The supervisor must insure that subordinates know the appropriate local directives as well as those of higher command. Subordinates must also be trained in supply discipline, which will be discussed later in this section. Next, we look at the responsibility a person has for property that he uses.

Custodial responsibility. Custodial responsibility is that responsibility which must be assumed by an individual who has acquired physical possession of Government property. The word "custodian" means caretaker. He is personally responsible for such property if the property is (1) issued for his official or personal use, whether or not he has signed a receipt for it; (2) under his direct control for storage, use, custody, or safeguarding; or (3) found (indicating possible loss, theft, or abandonment) under circumstances requiring his personal care, custody, or protection.

Property issued to an individual does not become private property by the act of issue, whether the issue was for official or personal use. It remains public property at all times and, as such, must be safeguarded adequately.

A person may, and often does, have more than one type of responsibility. Take the case of the desk and chair used by the commander. The commander has both command and custodial responsibility. A supervisor of a secretary has supervisory responsibilities for the desk and other office equipment used by his secretary. He also has custodial responsibility for the desk and office equipment he uses. From these examples, we can think of many conditions which could place more than one type of responsibility with an individual. The person finding public property is responsible for its care and protection until it can be returned to the responsible person. The person finding the property is required by AFR 67-10 to place it back into the supply channels. Now that we know the types of responsibility, we should also learn the conditions under which we may be relieved of responsibility.

Exercises (048):

Among the following statements about Air Force property responsibility, identify both the true and false statements. Write T for true and F for false by each, explaining why those false are incorrect.

- 1. The title to AF property is not held by one individual but is held jointly by Congress and the President.
- 2. Congress passed a law in March 1894 that holds individuals responsible for public property.
- 3. In your duty section, your supervisor and your commander have the responsibility for the property you are using.
- 4. Pecuniary liability means that we must make good for the loss, destruction, or damage of property caused by our maladministration or negligence.
- 5. The property you use in the performance of your duty is your responsibility even though ownership for that property is retained by the Air Force.
- 6. Commanders are exempt from pecuniary liability.
- 7. The commander must know all of the minute details required for recordkeeping.
- 8. Supervisory responsibility applies to any person who exercises supervision over property.
- 9. The supervisor is normally near the property for which he is responsible.
- 10. Supervisory responsibility does not extend to that property in transit or in storage.
- 11. A commander can have supervisory as well as command responsibility if he has people working directly under his supervision.
- 12. A custodian is personally responsible for Government property when it is issued for his official or personnel use, and he has a signed receipt for it.
- 13. A person may have supervisory as well as custodial responsibilities.
- 14. If you found a multimeter on base you would have the responsibility to place it back into the supply channels.

049. Given typical situations, describe for each the method that should be used to provide relief from property responsibility and accountability.

Relief From Property Responsibility. We have mentioned the circumstances under which property responsibility is assumed. Now, how can we be relieved of property responsibility? The condition of the property is an important factor when we are being relieved of property responsibility. The property we seek relief of responsibility from may be serviceable, unserviceable through fair wear and tear, or lost, damaged, or destroyed. Pecuniary liability may be involved when you are being relieved from property responsibility. (Pecuniary liability means the responsible person pays for the loss.) For the time being, we will postpone our discussion of relief from property responsibility under these conditions. Instead, we will explain how to be relieved where pecuniary liability is not involved. There are two ways by which this can be done—by turn-in or by transfer. These apply to property that is serviceable or unserviceable. However, the items that are not serviceable must be considered to have been damaged by fair wear and tear.

Turn-in. The turn-in of property means putting it back into the supply channels. If the property is not serviceable, it is transferred to a repair activity. If it is beyond repair, it is transferred to the disposal unit. Procedure for disposal depends upon the property involved. Serviceable items are turned in for reissue. When you have an item signed out from EMO (Equipment Management Office) and you don't need it, turn it in. For instance, suppose you

have an adding machine signed out and it is no longer needed; return it to EMO and pick up your receipt. If no one else in the organization has a requirement for the machine, EMO returns it to Supply. Supply will then look to see whether or not another organization has a need for the machine. If no requirement for the machine exists, it may be disposed of. This can be done by shipping it to another base or depot or to the local Defense Property Disposal activity. Each of these transactions will be documented to relieve each individual or activity of responsibility for the machine. Such transactions occur frequently. When the turn-in is properly documented, relief of responsibility and accountability for the property is obtained. Now, what methods are used to obtain relief from property responsibility when property or people are transferred?

Property transfer. The transfer of property, as used here, means changing its physical location or user. If the user of the property changes, custodial responsibility moves to the new user. For example, say the commander wants a new desk; he sends his old one to a section that needs it. Custodial responsibility for the old desk then moves to the user in the other section. Another example is provided by an item that has a serial number. The physical location of such items is entered on property records. An example would be transferring a typewriter from the orderly room to another section in the same organization. This type of transfer relieves the people in the orderly room of supervisory and custodial responsibilities. The command responsibility for the typewriter remains with the squadron commander. Had the typewriter been transferred to another squadron, the commander would be relieved. These examples show that property responsibility goes with custody or jurisdiction.

Transfer of personnel. When a person who is responsible for property is transferred, and the property remains with the organization, property responsibility also stays in the organization. Some of the items of property for which the individual has custodial responsibility may be returned to Supply. His records and had receipts then are cleared of these, so that he may depart from the base. Let's say that the individual is a supervisor and his replacement is not on base to sign for the remainder of the property. In such an event, the next higher supervisor will normally be held responsible for the property until the replacement arrives.

Exercises (049):

In each situation that follows decide the action that should be taken to be relieved of property responsibility and accountability.

1. You are a shop chief located on an overseas base and have received your orders for return to stateside duty. Your replacement hasn't arrived, and you must be relieved of the supply account. What should you do?
2. Your branch has 12 extra straight-backed chairs due to personnel losses. Headquarters section is in need of extra chairs, but only wants to borrow instead of signing for them. Should the chairs be turned in to Supply or should they be loaned? Give the reason for your choice.

050. Given a series of statements about settling property obligations with the Air Force, distinguish those true from those false, telling why the latter are incorrect.

Here we discuss pecuniary liability, what it is, and when it is not admitted.

Pecuniary Liability. Pecuniary liability applies to all personnel having property responsibility. It means we must make good the loss, destruction, or damage of property caused by our maladministration or negligence. Pecuniary liability may be shared by persons having command, supervisory, and custodial responsibility. The person or persons with responsibility for the property will have to reimburse the Air Force. If not, the Air Force will have to stand the loss. There are four methods used to settle an obligation to the Air Force.

They are: (1) Government property lost or damaged survey, (2) report of survey, (3) cash collection voucher, and (4) statement of charges.

To determine which of these methods will be used, we will first have to learn whether pecuniary liability is admitted or not admitted.

When Pecuniary Liability Is Not Admitted. Two methods of being relieved of property responsibility when pecuniary liability is not admitted involve the Government property lost or damaged survey and the report of survey. These two forms must also be used when the price of an item is over \$250. Lost, damaged, or destroyed Government property must be accounted for at the earliest possible date. This must be done within 30 days, because the investigation must be made while the persons involved (including witnesses) are available and the facts are still fresh in the minds of those involved.

Government property lost or damaged survey. When a responsible officer discovers a lost or damaged item, he immediately conducts a preliminary investigation to determine whether or not there is any evidence of gross negligence, willful

misconduct, or deliberate unauthorized use. If the investigation shows no evidence of gross negligence, willful misconduct, or deliberate unauthorized use, he must prepare a Government Property Lost or Damaged (GPLD) Survey Certificate (AF Form 2444). This will be prepared in accordance with AFM 177-111, *Reports of Survey*.

The responsible officer will send this form to EMO, which will forward it to the base comptrollers office. If the cost of the item is under \$500, and the base comptroller agrees with the responsible officer, he will sign and return the certificate to EMO. EMO will then remove the item from the property listing. If the cost is over \$500, the base comptroller must forward it to the base commander for approval. If the comptroller does not agree with responsible officer that the loss or damage was not through gross negligence, willful misconduct, or deliberate unauthorized use, he returns it for a formal report of survey.

Report of Survey (DD Form 200). The report of survey is a means for explaining the loss, damage, or destruction of Government property. It also secures relief from responsibility. For this reason responsible individuals should include in it all pertinent facts and circumstances surrounding the loss. A surveying officer will investigate and try to determine whether or not there was any gross negligence or willful misconduct evident. If a report of survey is approved, all individuals will be relieved of responsibility, and the item will be dropped from the property listing by EMO. If, however, the report of survey is disapproved, the responsible individual will be required to reimburse the Air Force.

When Pecuniary Liability Is Admitted. Two methods of being relieved of property responsibility when pecuniary liability is admitted are the cash collection voucher and the statement of charges. To use these two methods, the damage or list price of the article cannot exceed \$250.

Cash collection voucher. The least troublesome way to settle a monetary obligation is to pay in some form of cash. The DD Form 1131 (Cash Collection Voucher) must be used when a cash payment is made. This form is generally prepared by the responsible officer (or EMO) to cover the cash collections for a particular period of time.

The voucher shows the complete Air Force description of the items involved and the purpose for which any collection was made. Negligence and carelessness are indicated as the causes of damage to the property. Before the money is turned in to the finance office, the cash collection voucher must be approved by the individual's commander. But what do we use to make the payment if we do not have the money with which to pay?

Statement of charges. Airmen and civilian employees use DD Form 362, Statement of Charges for Government Property Lost, Damaged, or Destroyed, when pecuniary liability is admitted but a payroll deduction is desired. This is used in lieu of a cash payment. A person signing a statement of charges has made an acknowledgment, an authorization, a waiver of a right, an affirmation, and an agreement. The commander must certify this form before it is submitted for a payroll deduction. However, even though the individual has paid for the loss, the property does not become the property of the individual.

Exercises (050):

For each of the following statements, write T if it is true and F if it is false, then tell why it is incorrect.

- 1. The cash collection voucher is used when the individual declaring pecuniary liability is willing to pay for the equipment through payroll deduction.
- 2. A Report of Survey (DD Form 200) is completed if the base comptroller does not agree that the loss of property was through gross negligence or deliberate unauthorized use.
- 3. When pecuniary liability is not admitted, the first form filled out is the Government Property Loss or Damaged Survey Certificate (AF Form 2444).
- 4. If an item costing \$240 was lost and pecuniary liability was not admitted, the Government Property Lost or Damaged Survey Certificate will be completed by the responsible officer.
- 5. When admitting pecuniary liability, property responsibility for a damaged item can be relieved by a statement of charges and a report of survey.

Data Reporting Systems and Forms

THE OLD SAYING, "The job isn't done until the paperwork is finished" was never more correct. The volume of paperwork has increased so much in today's Air Force that it is doubtful that the data processed could have been handled efficiently had not computers been developed. The question then is, "Why have all of the paperwork as long as the job gets done?" The answer is that the data reporting system is a management tool. The information gathered enables maintenance managers to use their equipment, manpower, and other resources more effectively.

In support of the data reporting systems, you will be required to record your actions or to review the efforts of others on aircraft and support equipment forms. Incomplete or inaccurate maintenance data will result in erroneous manning, equipment allocation budgeting, or unrealistic work requirements.

5-1. Maintenance Data Collection (MDC)

Management of the maintenance effort requires documenting and reporting of all maintenance actions. The maintenance data collection system provides for the recording of maintenance actions as they are accomplished. This section of your CDC is designed to give you a description of the MDC system and to explain how the data is documented.

051. Clarify maintenance data collection by citing the steps in the MDC system and principal uses of MDC information at the command and base level and by discussing one method of retrieving this material from the computer.

Maintenance Data Collection (MDC) System. The maintenance data collection (MDC) system is described as a system that collects all maintenance actions that involve direct or indirect labor and stores this information in a computer for future use. Basically the following takes place:

1. The collection process begins when the maintenance specialist documents maintenance data

on the AFTO Form 349. This data is verified for accuracy by the supervisor, keypunched, and processed through a computer onto magnetic tapes.

2. The data is stored on magnetic tapes and grouped into categories, such as "on-equipment," "off-equipment," etc. These groups are called records and each has a record name and number. This data is now added to the computer storage bank.

3. The data can be retrieved any number of ways, depending upon how the base requests it. One way is through the base level inquiry system (BLIS), which we will talk about later on in this same objective.

Now that we have seen how the maintenance data file is created, the potentials in the use of this file should be obvious. The file provides management with the accumulated data, which they can then compare against other stored data in order to identify problem areas and labor expenditures within the maintenance complex.

Accuracy of MDC data. Due to the multitude of uses made of the MDC system, the data must be as accurate as possible. A continuous effort by each individual and all levels of management is required to make this system pay the greatest dividends.

As an aid in reducing errors, both base level and AFLC computer programs provide error reports to bases and major commands. These reports should be treated as management aids, not as instruments to penalize individuals who accidentally caused errors. The full intent of these reports is to improve reporting and data utilization.

Editing procedures to detect errors are designed to check the validity of all data elements. These procedures are also designed to make cross comparisons between many of the codes in order to insure the compatibility of data. However, these editing procedures are limited by computer capability, time, program complexity, and the ability to validate entries, such as serial numbers. It is, therefore, a responsibility of each work center supervisor to assure the completeness and accuracy of all forms before he turns them in for keypunching. It is important that errors are actually

corrected, not just "doctored" to pass edit programs.

Command level use. The primary use of data provided to Air Force Logistics Command (AFLC) through the MDC system is to control various programs established by the air force, such as maintenance engineering and materiel management requirements. Here are some examples of the uses at command level:

- Analysis of high-rate-of-failure systems and components.
- Validation of inspection and time change intervals.
- Determination of the status of equipment modifications.
- Validation of manpower requirements.
- Validation of requirements for spare parts.
- Identification of systems which consume maintenance man-hours at an unusually high rate.

Base level use. The intended use of the base level maintenance production data is to provide information feedback to the base managers and supervisors for controlling the maintenance operation. This information makes it possible to effectively meet and support established operation and maintenance requirements. More specifically, at base level, the MDC system provides these things:

- Production credit information regarding the type of work accomplished, the work center(s) that did the work, and the equipment on which the work was accomplished.
- Equipment maintenance schedules and inventory.
- Direct labor hour expenditures by the work center. This includes labor expended for tenant activities on special projects.
- Materiel failures and equipment discrepancies.

Data in the MDC system is made available to base level maintenance activities through daily or monthly reports. Daily error listings are also produced at base level to aid in maintaining accurate information. Another way of retrieving data from the computer, besides the daily or monthly reports, is by means of the base level inquiry system (BLIS).

Base level inquiry system. One of the main advantages of the base level inquiry system (BLIS) is that it eliminates voluminous MDC (recurring) reports in favor of demand inquiries. Another advantage is that BLIS gives maintenance managers a means to selectively retrieve MDC information. This information is retrieved on an "as needed" basis from the MDC data bank. Data may be selected either from the current month's data or from the historical file containing data for the previous 6 months. The BLIS was designed both to make the MDC system easier to use and to give management a more effective management tool.

Thus, in BLIS the number of output products available to you is limited only by the imagination of the selector and by the machine time available. The flexibility of these output products makes it possible to retrieve specific information. This information will help to quickly, and with least effort, answer such questions as: (1) How many direct man-hours were expended on a given job (unit of work)? (2) What was done to effect repair (action taken)? or (3) How many jobs were accomplished by work center A during the past 6 months?

The main point to keep in mind about the uses of the MDC system is that it does not provide solutions of problems but merely identifies problems for management, which must then decide on the appropriate actions.

AFM 66-267, *Maintenance Data Collection*, describes base level use of the collected data and should be consulted if questions arise.

Exercises (051):

1. List the three steps in the MDC system.
2. Tell three uses made of the MDC information at command level.
3. Give three uses made of the MDC information at base level.
4. What is the base level inquiry system (BLIS)?

052. Concerning documentation categories and AFTO Form 349's relationship thereto, identify the category types and, by its color, the use of an AFTO Form 349, telling why coded information is used on this form.

Two related topics, documentation categories and AFTO Form 349, are our topics here.

Documentation Categories. All maintenance data is grouped into one of three categories. (1) Data documented to describe maintenance performed on end items (i.e., aircraft, ground power units, etc.) is categorized as "on-equipment." In contrast, (2) data documented to describe maintenance performed on assemblies, subassemblies, or components that have been removed from an end item is categorized as "off-equipment." Both on-equipment and off-equipment documentations are classified as productive direct labor. (3) The third category,

"productive indirect," identifies those hours that are expended for leaves, details, compensatory time off, training, and alert duty. By documenting within the appropriate categories, managers will have available data which fully describes where, when, what, and how maintenance production resources are used.

AFTO Form 349. The AFTO Form 349 is a multipurpose form used to document all on-equipment, off-equipment, and productive indirect actions. It serves as a work monitoring record in the maintenance activity, provides a record of work performed, and also dispatches specialists to the job. Additionally, at major command or local option, the AFTO Form 349 may be locally reproduced on colored paper stock. If colored forms are used, they can be used for various other purposes as follows:

Action	Paper Color
Time compliance technical order (TCTO)	Green
Cannibalization	Blue
Time change items	Yellow
Quality control writeups	Pink

Figure 5-1 illustrates the front and back of an AFTO Form 349. Notice that it has 28 blocks on the front side and two on the back. Notice also that it provides five action lines for recording maintenance actions on the same end item. This reduces the number of forms on which basic end-item identification must be recorded. Only selected blocks are required for use at any one time depending upon the job being documented. You should never have all these blocks filled out for any one maintenance action. Coded information is used in these blocks to simplify data recording, to standardize documentation, and to reduce writing time for the maintenance personnel. Also, the use of codes facilitates data retrieval, because coded information can be processed through computers to produce reports and summarize data. These codes are found in the TO 00-20 series and the appropriate aircraft "06" technical orders. Examples of coded information are shown in foldout 1, found at the back of this volume, which has been extracted from a C-130 work unit code book.

Exercises (052):

1. List the three categories of maintenance data.
2. If an AFTO Form 349 was colored green, what would this indicate?

3. Why is coded information used on the AFTO Form 349?

053. Cite the uses of entries made in selected blocks of an AFTO Form 349 and, given a simulated maintenance situation, complete a typical AFTO Form 349.

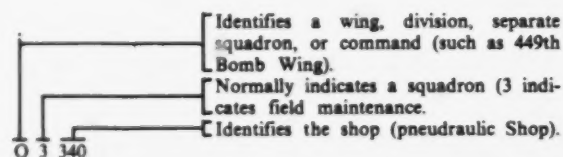
AFTO Form 349 Entries. Now that we have an understanding of that for which the AFTO Form 349 is used, we need to see how and where the data is actually recorded on this form.

The information listed in the following paragraphs has been condensed from the 00-20 series technical orders. It is not meant to be a complete reproduction of the technical information concerning the AFTO Form 349. There is, however, sufficient information given to complete the problem in this text. Always remember that you must check the latest applicable technical orders when you are checking entries in an actual maintenance situation. Also, keep in mind that recording procedures will vary somewhat, depending upon whether on equipment, or off-equipment maintenance is being performed.

Blocks on AF Form 349. To complete this section of the text, refer to the AFTO Form 349 shown in figure 5-1 as you read the following material covering each block on the form.

a. Block 1, Job Control Number (JCN). The JCN contains seven digits. The first three are made up of the Julian day. For example; the Julian day for the 10th of February is 041 (the 41st day of the year). The last four digits are used to identify jobs and normally consist of a daily or monthly job sequence number, such as 0001 for the first job of the day or month. The JCN would be 0410001 for the first job assigned on February 10th. The JCN ties together all on- and off-equipment actions taken on the same job, including man-hours expended and parts consumed. This procedure permits the control of all related actions, and identifies the total job for analysis purposes.

b. Block 2, Work Center. This work center designator is a standard 5-character code made up as shown in the following example:



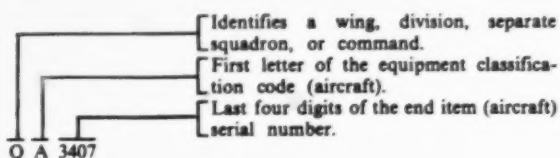
AFTO FORM 349
MAY 78

PREVIOUS EDITION IS OBSOLETE.

CONTINUATION FROM BLOCK 10.

95

c. Block 3, ID No./Serial No. This is a 6-digit identifier assigned to the equipment for which the work is required. It is normally made up as follows:



If no ID number has been assigned, enter the last eight digits of the end item serial number.

d. Block 4, MDS. If an ID number is entered in block 3, an entry is not required in block 4. If a serial number is entered in block 3, enter the mission, design, and series of the equipment (such as C-130A).

e. Block 5, EQ/CL. The equipment classification (EQ/CL) code is used to identify the equipment on which an action was required that generated the maintenance data. Do not confuse the function of this code with the equipment identification number, which we have discussed earlier. The EQ/CL code consists of three characters. The first character identifies a general class of equipment, such as A for aircraft. The last two identify a specific type of aircraft. For example: the EQ/CL code for a C-130A aircraft is "A CF" and for a C-130H, it is "A CK." Figure 5-2 is an extract from TO 00-20-2, attachment 2, that shows a portion of the equipment classification codes. If an ID number is entered in block 3, an entry is not required in block 5. When block 3 contains a serial number, enter the applicable equipment classification code from TO 00-20-2, attachment 2.

f. Block 6, Time. End item time is required only when reporting the removal and replacement of a serially controlled or time change item. These items are identified by an asterisk in the work unit code manual. See work unit code 1321S, in foldout 1, part G.

g. Block 7, PRI. When used as a dispatch form, enter the priority of work that was established by maintenance control.

h. Block 8, Sortie No. The documenting of sortie numbers is a command or local option.

i. Block 9, Location. When used as a dispatch form, the actual location where the work will be performed is entered. For example, "C-14" could direct you to aircraft parking row C, parking slot 14.

j-l. Blocks 10 through 13. Entries are required in these blocks only to record the removal or installation of an engine.

m-o. Blocks 14 through 16. No entries are required unless such are directed by local management.

EQUIPMENT CLASSIFICATION CODES

KC-97	A CE
C-130A & D, RC-130	A CF
C-118A & VC-118A	A CG
C-130E	A CH
C-130H	A CK
C-119G&J	A CJ
C-121C&G	A CL
AC-47	A CM
C-9A	A CN
C-123B & J	A CP
C-124	A CQ
C-130B	A CR
C/VC-131A, C-131E	A CS

Figure 5-2. Equipment classification codes.

p. Block 17, Time Spec Req. An entry is required only when used as a dispatch form. The time the work is scheduled to start is based on a 24-hour clock, for example 0830.

g. Block 18, Job Standard. An entry is required only when used as a dispatch form. This entry will be the standard or estimated clock hours (not man-hours) needed to perform the job, for example, 2.5.

r. Block 19, FSC. Enter the national supply classification (NSC) code of the item. The NSC comprises the first four digits of the national stock number. This block will never be left blank for off-equipment work.

s. Block 20. Enter the part number of the item as it appears on the data plate, including all dashes and slashes. For items that do not have a part number, enter the national item identification number (NIIN). The NIIN constitutes the last nine characters of the national stock number. This block will never be left blank for off-equipment work.

t. Block 21. Enter the serial number of the item being removed. If the serial number exceeds 10 digits, enter only the last 10 digits. The Oper Time portion of the title will be lined out to indicate serial number.

u. Block 22. Use only when documenting removal of time change or serially controlled items.

Enter the last three digits of the AFTO Form 350 tag number.

V. Block 23. Enter the identification of the item being installed. Preference for identification is the same as in instructions for block 20.

W. Block 24. Enter the serial number of the item being installed. If the serial number exceeds 10 digits, use only the last 10.

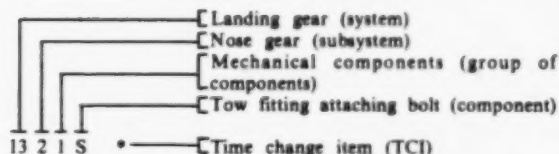
x. Block 25. Used only for time - change items. Enter the previous operating time of the item being installed.

Action line entries. Line entries across the center portion of the form have been identified by the numbers 1 through 5 so that entries on the back of the form can be related to the appropriate line number. Refer to foldout 1, which has extracts from the 1-06 work unit code manual.

a. Column A. Enter the type maintenance code that identifies the type of maintenance performed. (See foldout 1, part B.)

b. Column B. The component position code is a one-digit numerical character that identifies the position of an installed engine. No entry is required in this block unless you are working on an installed engine.

c. Column C. Work unit codes, other than support general codes, identify the system, subsystem, and component that work was accomplished on. Refer to foldout 1, part G, and find the nose gear tow fitting attaching bolt. Work unit code 1321S* is broken down as follows:



d. Column D. Enter the code that identifies the action taken on the item identified in column C. (See foldout 1, part C.)

e. Column E. Enter the appropriate code to indicate when the defect or need for maintenance was discovered. (See foldout 1, part D.)

f. Column F. Enter the how malfunctioned code from the -06 that best describes the nature of the malfunction of the item described in column C. (See foldout 1, part E.)

g. Column G. Enter the number of times that the action identified in column D was taken against the item or support general code identified in column C.

h. Column H. Enter the hour (24-hour clock) to the nearest 5 minutes that the job described by the line entry starts.

i. Column I. Enter the Julian day and hour (24-hour clock) to the nearest 5 minutes that the job described by the line entry stops. The start and stop time entries will be completed to close out the line entry for any delay or work stoppage which exceeds 15 minutes as well as for crew size or category of labor changes.

j. Column J. Enter the number of personnel involved in the job for the line entry. When the crew size is greater than 9, a second line entry is required to show the balance of personnel.

k. Column K. This element is used to identify the type of man-hours expended. Figure 5-3 shows the category of labor codes from TO 00-20-2, attachment 4.

l. Column L. All AFTO Forms 349 for maintenance performed on equipment with no ID number assigned must have the two-position command code (OJ for the air training command) of the owning command entered in this column. For all other maintenance tasks, this column is optional.

m. Column M. This column is used for documenting recurring maintenance on precision measurement equipment (PME), and communication-electronics-meteorological (CEM) equipment. Except for the situation just stated, this column is left blank.

n. Column N. Enter the five-character employee number. The employee number is assigned by a computer program to identify the person that has recorded a maintenance action.

o. Block 26, Discrepancy. A complete description of the discrepancy or work to be performed is entered in block 26 (DISCREPANCY). For on-equipment support general maintenance, no entries are required in block 26. In this case, the entries in columns A through K are enough to identify the work.

p. Block 27, Corrective Action. Enter a brief but specific description of the work accomplished to correct the discrepancy. An entry is not required for on-equipment support general activities (servicing with oil, hydraulic fluid, etc.) or a minor fix.

q. Block 28, Records Action. A checkmark is placed in block 28 to distinguish maintenance actions that affect the historical records of an end item. If the Records section initiates the form for a scheduled component replacement or a TCTO, a checkmark is made to allow the form to be returned to the Records section. Unscheduled time-significant replacements require the person completing the action to check block 28. This signifies that the action affects the historical records of the end item.

r. Block 29, Parts Replaced During Repairs. You enter the identification of components and parts consumed in making repairs in block 29 (reverse side) of the AFTO Form 349. Entries are

CATEGORY OF LABOR CODES

<u>DATA ITEMS</u>	<u>DATA CODES</u>
Military, Regular Duty Hours	1
Military, Overtime Hours	2
Federal Service Employee-Regular Duty Hours	3
Federal Service Employee-Overtime Hours	4
Local National Employee Hours	5
Contractor Labor Hours	6

Figure 5-3. Category of labor codes.

required for nonreparable nonrecoverable items. The consumption of common hardware items such as nuts, bolts, screws, washers, safety wire, clamps, common gaskets and seals, hose connections, etc., are not reported.

s. Block 30. Continuation From block ____ . This block will be used for continuation of blocks 26 or 27, or as prescribed by local directive.

Exercises (053):

1. What block entry identifies the particular item of equipment on which work is to be performed?
2. What unit supplies the priority which is posted in block 7 of the AFTO Form 349?
3. Under what condition is block 9 of the AFTO Form 349 used?
4. What does the number 0900 entered in block 17 of the AFTO Form 349 indicate?
5. If a job standard has not been established for a particular task, what entry is made in block 18 of the AFTO Form 349?
6. Under what condition is the NIIN (national item identification number) entered in block 20 of the AFTO Form 349?

7. Which action line entry on the AFTO Form 349 identifies the specific unit on which work is being performed?

8. What entry ties together all on and off-equipment actions taken on the same job?

9. What would be entered in block 4 if a serial number were entered in block 3?

10. Use the following information and the excerpts from TO 1C-130A-06 in foldout 1 to complete the AFTO Form 349 in figure 5-1.

- a. You are sent on a work order to remove and replace a leaking nose landing gear actuating cylinder. It was found between flights by the ground crew.
- b. This is the 12th job assigned by Job Control on the 27th of January. The job is assigned priority 2. The aircraft is on spot B7. The job is scheduled to start at 8:30 a.m. and will take approximately 3 hours.
- c. You are dispatched to do the job and get to the aircraft at 0830. You complete the job in 2 hours.
- c. You are dispatched to do the job and get to the aircraft at 0830. You complete the job in 2 hours.
- d. Your employee number is 78436. The aircraft ID number is QA3407. Your work center code is Q3340.

054. Describe briefly selected entries made on an AFTO Form 349 pertaining to productive indirect labor.

This LO concentrates on productive indirect reporting and form entries related thereto.

Productive Indirect Reporting. No matter what your work load is in the shop, there will be instances when you will not be performing direct labor. Some of these instances would be for Commanders Call, leave, and comp time for overtime. These are called productive indirect labor and are reported on the AFTO Form 349. Reporting procedures are found in the 00-20-2 series technical orders.

Form entries for productive indirect labor. The AFTO Form 349 will be completed as follows when productive indirect labor is involved:

1. Block 1. Enter the job control number assigned by maintenance control.
2. Block 2. Enter the work center code of the individual actually performing the indirect labor.
3. Block 3. The ID number entered in this block will be the first position of the work center code to which the individual is assigned, followed by INDLB, for indirect labor. Example: QINDLB.
4. Column C. Enter the unique work unit code which reflects the type of productive indirect labor being reported. These codes can be found in all equipment -06 work unit code manuals. (See foldout 1, part F.)
5. Column H. Enter the hour (24-hour clock) to the nearest 5 minutes that productive indirect labor was started. For leave and compensatory time for overtime, the start time will always be during normal duty hours.
6. Column I. Enter the Julian day (001-366) and hours (24-hour clock) to the nearest 5 minutes that productive indirect labor was terminated. For leave and compensatory time for overtime, this entry will always be during normal duty hours.
7. Column J. Enter the number of personnel involved in the productive indirect task.
8. Column K. Enter the category of labor which reflects the status of the individual involved.
9. Column L. Use of this column is optional.

Exercises (054):

1. What does the INDLB in the ID number block of the AFTO Form 349 mean?
2. Where are the work unit codes located for productive indirect labor?
3. Tell how the start and stop time for compensatory time for overtime will be entered.

5-2. Aircraft and Supporting Maintenance Forms

Your responsibilities as a maintenance man to the aircraft records and other aircraft documents will vary with assignments. We hinted in an earlier chapter that you will maintain equipment, train, and eventually supervise other personnel. A high percentage of these tasks will be recorded in aircraft or aircraft related forms.

055. Briefly explain some standard practices and entries used to complete the AFTO 781 series forms.

There are certain standard practices that you must adhere to in your use of these forms. As a minimum we will discuss legibility, signatures, dates, and abbreviations. Any other cautions or requirements will be noted as they apply to the form under discussion.

Uniform Entries. A more-than-ordinary effort should be made to make the entries complete, correct, legible and neat. These records are handled by various personnel who must file, extract information, and make out other records and forms from them. It is therefore of the utmost importance that you make the entries proper and legible—or have them made so—to reduce the possibility of errors caused by someone's misinterpretation of our careless entries. To achieve correct and legible entries, it is recommended that they be made with pencil to allow correction of minor errors. Although discouraged, it is not an error to make entries in ink.

The minimum signature used on most maintenance forms is the first name initial, complete last name, and rank or grade. This entry is always made in script by the actual person; it is printed if transcribed to other documents by another individual. Exceptions exist to this policy as there are with nearly all policies, but they are rare.

The dates used on these forms generally consist of five digits separated by slashes. That is, the day is recorded by using two numerals, the month two, and the year only one numeral. An example for the date 12 January 1975 is 12/01/5. An exception to this rule is the use of six numerals when recording the dates on some positions of the AFTO Form 350. These exceptions are primarily attributed to the fact that the information on this form is transferred to computer punch cards.

Abbreviations. The last area we will cover before the actual forms is abbreviations. Standard abbreviations that aid in a concise and readable form entry are recommended. Remember, though, the key to remember when you are using any shortened word form is "Will the reader understand?" If you cannot answer this question in the affirmative, you should spell it out. Several standard abbreviations are listed in the first section

of TO 00-20-1; e.g., DN for "document number" or IAW for "in accordance with."

Exercises (055):

1. Why are the accuracy, neatness, and legibility stressed in the handling of AFTO 781 series forms?
2. According to the 00-20 series technical orders, what constitutes a minimum signature for most aircraft forms?
3. Generally speaking, if you were writing the date October 15, 1974, on aircraft forms, how would you record it?
4. What standard rule should be adhered to in using abbreviations?

056. Concerning symbols used on aircraft maintenance forms, give the purpose and meanings of selected symbols and name the proper symbol for typical situations.

Symbols and Their Use. Certain symbols described in this section are established for use on maintenance documents to make important notations instantly apparent. They indicate the mechanical condition, fitness for flight or operation, servicing, inspection and maintenance status of the system concerned. Of these, particular symbols are entered in red to make the important warning signals stand out more clearly. Thus, the red X represents the most serious possible condition; the circled red X, the next most serious condition; the red dash, the next most serious; and the red diagonal, the least serious condition. You must memorize the relative importance of these symbols to insure proper entries on maintenance forms.

You enter these symbols on several of the AFTO 781 series forms, giving the Status Today block of the AFTO Form 781H the most attention. Remember, these symbols reflect the seriousness of the discrepancy in the opinion of the individual making the entry. If a person of higher authority within the maintenance activity believes the symbol chosen does not properly reflect the condition, he may upgrade or downgrade the symbol to one he considers more appropriate.

Once entered on any maintenance document, as symbol must never be erased, even if it has been entered in error. This restriction on erasing symbols is necessary to insure that the opinion of the individual who made the entry is thoroughly evaluated before a symbol is changed and that even an erroneous symbol entry is properly cleared. In this way no doubt is left about the integrity and validity of the symbol entered. If an erroneous symbol is entered in the Sym block of the AFTO Form 781A, the individual making the entry will enter the following statement in the Corrective Action block: "Symbol entered in error, item reentered page _____, item _____." The discrepancy will then be entered in the next open Discrepancy block, with the correct symbol. As an example, if the erroneous symbol is a red X, and authorized individual must initial over the symbol and sign the Inspected By block.

Red X. As already indicated, the red X is the most serious symbol. It indicates that the aircraft is considered unsafe or unfit for flight and must not be flown until this unsatisfactory condition has been remedied. No one may authorize or direct that an aircraft be flown until the red X has been properly cleared. After work has been done to clear the discrepancy, there must then be an audit of all related entries involved. They must be checked for completeness and accuracy. Each red X symbol will always be a separate AFTO Form 781A entry. The following are some of the typical situations which call for the use of the red X symbol:

a. Immediately upon discovery of an unsatisfactory condition serious enough to warrant its use.

b. Upon receipt of an immediate action technical order.

c. When work or inspections are performed in or around the air intake areas of jet engines. The red X must be used to insure inspection of the engine intake ducts and areas forward of the intake ducts. This inspection must be accomplished prior to engine start to insure that there are no objects that could be ingested by the engine.

d. When maintenance is performed on aircraft flight control systems or components.

e. When maintenance or aircrew reported defects or unsatisfactory conditions of systems or components exist that could affect safety of flight—defects or conditions which cannot be physically located or cannot be operationally duplicated.

f. Upon removal of any component or assembly that affects safety of flight or safe operation of the equipment.

g. When the removal and replacement of any component or assembly is such that improper reinstallation would affect flight safety or create an operational hazard.

h. When a weapon or support system is out of commission for an engine change.

i. When a scheduled inspection is in progress for a weapon or support system or equipment, excluding preflight (PR), thruflight (TH), basic postflight (BPO), and home station check (HSC) inspections on aircraft and daily inspections on missiles or other equipment. The decision to apply the red X for preflight, basic postflight, and daily inspections will rest with the maintenance supervisor or higher local authority.

j. When an egress system has been partially or completely disassembled.

k. When maintenance is performed on the fuel system or any fuel system component while installed on the aircraft or auxiliary power unit (APU).

l. When an aircraft brake or nose gear steering system is inoperative. Aircraft with inoperative brakes must not be towed or taxied until the red X symbol has been cleared. However, this restriction may be waived by the maintenance supervisor or chief of maintenance under emergency conditions.

m. When a "jump wire" or other type of shorting device is installed in an electrical system while maintenance is being performed.

n. When the aircraft weight and balance status is unknown.

Circled red X. The circled red X is used to indicate that the aircraft has been grounded, pending compliance with an urgent action technical order. When an urgent action TCTO is received and is not immediately started, it is placed in the aircraft forms on a red diagonal. A time limit is attached to the compliance of this TCTO (usually from 1 to 10 days). When this time limit expires, or when work is started, a circled red X is entered in the aircraft forms. The circled red X is treated in the same manner as is the red X.

Red dash. The red dash symbol indicates that the condition of the equipment is unknown. This symbol denotes that an inspection is due and has not been completed; that a functional check flight has not been made; or that an accessory, though scheduled for replacement, has not been replaced. So you can see that the red dash may be an erroneous symbol, in that a red X condition could exist, since the equipment has not been examined to ascertain its true condition. The red dash symbol requires an exceptional release in block 9 of AFTO Form 781H, if the aircraft is to be flown. The exceptional release will be discussed later when we cover the AFTO Form 781H.

Red diagonal. The red diagonal indicates that an unsatisfactory condition exists which may affect the flying safety or the flying efficiency of the aircraft, but it is not sufficiently urgent or dangerous to warrant grounding the aircraft. The diagonal is entered in the appropriate block, extending from the upper right-hand corner to the lower left-hand corner of the block. This symbol also requires an

exceptional release in block 9 of the AFTO Form 781H.

Black last name initial. The black last name initial indicates that the aircraft is in a satisfactory condition for use. The black initial may be placed over a red symbol to indicate that the condition has been corrected. Therefore, a red symbol is never entered over an initial—you must use the next open block to indicate the change in condition from satisfactory to unsatisfactory.

Exercises (056):

1. What do red symbols in aircraft maintenance forms represent?
2. Name the status symbols used on aircraft forms in descending order.
3. When is it permissible to erase a red symbol? Explain briefly.
4. If your wing received an immediate action technical order, what symbol would you select to enter in the forms?
5. If personnel under your supervision had started work on an urgent action TCTO, what symbol would you expect to see in the AFTO Form 781A and 781H to represent this condition?
6. Simply stated, what does a red dash represent?
7. A discrepancy that may affect the flying efficiency or flying safety of the aircraft, but which is not sufficiently urgent enough to ground the equipment, would be represented by what symbol?
8. If you saw a black last name initial over a red symbol in the aircraft forms, what would it mean?
9. Give the purpose of using red symbols.

057. Given specific maintenance data and typical situations, select and record the appropriate information on the AFTO Form 781A provided.

AFTO Form 781A. This form is designed so that each individual deficiency and discrepancy reported by the pilot or an aircrew member, or discovered by the maintenance personnel, can be identified and documented for historical and filing purposes. The form, shown in figure 5-4, is identical on the front and back sides; it contains spaces for four different discrepancies on each side. Each side is treated as a page when the completed forms are removed from the aircraft binder, and forwarded to the records unit for filing.

The heading line at the top of the form is filled in, as indicated in figure 5-4. The examples given show typical entries for these blocks. The one item that might need clarification is dating. The Date From and To blocks denote when that particular set of forms (those consecutively page numbered) were initiated and closed out. The Date From block indicated that the last set of forms were removed on that date, while the To date indicates the date on which those forms were removed from the binder and forwarded to the documentation section. It is important for you to remember that the date placed in the Date From block of the new set of forms is the same as the TO date that appeared on the previous set. This rule must be followed to provide a positive means of determining whether any forms are missing from the aircraft file.

The headings on succeeding pages need not be as complete as shown on this sample first sheet. For instance, the second page and all other even-numbered pages of that set would need only a page number. The third page and all other uneven-numbered pages would require a minimum of page number From and To dates, MDS, and serial number. This would mean that if four sheets were removed from the aircraft binder at the same time, they would be securely fastened together and would carry the same From and To dates, with a page numbering notation, such as Page 1 of 9 Pages, Page 2 of 8 Pages, etc., through Page 8 of 8 Pages.

Discrepancy block. The Discrepancy block is used to note any defect that exists on the aircraft, whether it is due to accident, deliberate removal, fair wear and tear, or something else. Only one defect is entered in any one block. Pilots making entries indicate the flight number as the first portion of the defect entry, as shown by the first discrepancy in figure 5-4. If the aircraft is radioactive, if the oil has been diluted, or if the engines have been placed in storage, the Discrepancy block is used to denote these conditions.

The blocks above the Discrepancy block serve to clarify and control information contained in it. We have already discussed symbols and dating, but the

remaining three will be covered here. The WDC block represents the when discovered code and is entered by the pilot if anything has been discovered in flight.

One of the methods used in identifying, controlling, and analyzing maintenance actions is the job control number. This seven-digit code is issued by plans and scheduling, either directly or in blocks, to maintenance activities for their use. Each code is unique to the job to which it is assigned and stays with that job until its completion. For example, when the fuel flow transmitter, indicated repaired in figure 5-4, is routed into the shops for repair, that JCN (0102502) will appear on all the maintenance documents relative to its repair until the transmitter has been made serviceable or has been condemned. You can easily see the advantage of using this date code if a complete job has to be traced or broken down. The JCN, as you have seen, is a seven-character code.

The Tag Number block is another control device used in keeping track of reparable property. When a technician performs a repair on a piece of equipment, he records this work accomplishment on the AFTO Form 781 series forms. This work is also recorded, for statistical purposes, on another form, the AFTO Form 349. If that repair action involves reparable property, the AFTO Form 350, will also be initialed. This form is attached to the part by the maintenance technician. The tag number that appears on the AFTO Form 781A is taken from this form.

The Discrepancy block, as we have mentioned earlier, is used to record the malfunction or deficiency in the words of the individual discovering the condition. Only one discrepancy is allowed per block, although as many blocks as needed may be used if the explanation is lengthy. The person who generates the writeup signs in the Discovered By block, with at least the minimum signature, as shown in the last discrepancy in figure 5-4. You will note that only the last entry has a signature in the Discovered By block. This is a convenience allowed aircrew personnel when making consecutive entries in the forms for one flight. All discrepancies are entered by all aircrew personnel, and the last is usually signed by the aircraft commander.

Before we go on to the Corrective Action block, we should briefly explain the entry in the DN or Document Number block. This entry, similar to the job control number, identifies the organization and date of the supply transaction. We'll only mention here that these codes have four parts. Using our document number from the second entry in figure 5-4 (X103FL 4010 2211), it breaks down thus:

X—service or priority (expedite).
103FL—requisitioner or organization.
4010—Julian date for 10 Jan 1974.
2211—transaction serial number.

DATE FROM		TO		CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.
10/01/4				C. PADGETT SSGT	437 MAWG	CHARLSTON AFB S.C.	C-141A	66-230
SYM	DATE DISCD	WDC	JCN	TAG NO.		CP TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
W	10/01/4	D	0102501			P 1		
DISCREPANCY						CORRECTIVE ACTION		
FLT No. 1 PILOTS LEFT SIDE						REMOVED AND REPLACED PILOTS		
PANEL LIGHTING INOP						LEFT SIDE PANEL REHOSTAT		
						DATE CORRECTED		
						11/01/4		
DN				DISCOVERED BY		CORRECTED BY		INSPECTED BY
X103FL40102135						R. Wilson Ssgt.		
SYM	DATE DISCD	WDC	JCN	TAG NO.		CP TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
W	10/01/4	D	0102502	774444		P 1		
DISCREPANCY						CORRECTIVE ACTION		
LOST FUEL FLOW ON No. 1 ENGINE						REMOVED AND REPLACED No. 1		
T.O. PLUS 1hs. ALL OTHER						ENGINE FUEL FLOW TRANSMITTER		
INSTRUMENTS NORMAL						SYSTEM CK OK IAW T.O.		
						1C-141-2-4, PARA 8-31		
						DATE CORRECTED		
						11/01/4		
DN				DISCOVERED BY		CORRECTED BY		INSPECTED BY
X103FL40102211						P. Scherer SSGT		A. Neekerson Maj
SYM	DATE DISCD	WDC	JCN	TAG NO.		CP TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
P	10/01/4	D	0102503			P 1		
DISCREPANCY						CORRECTIVE ACTION		
CREW LAVATORY DOOR WILL NOT						ADJUSTED LOCK. OPS CK. OK.		
LOCK.								
						DATE CORRECTED		
						11/01/4		
DN				DISCOVERED BY		CORRECTED BY		INSPECTED BY
				B. Beukli Maj		C. Padgett SSGT		
SYM	DATE DISCD	WDC	JCN	TAG NO.		CP TO 781A DATED	TRANSFERRED TO 781K DATE	TRANSFERRED BY
						P 1		
DISCREPANCY						CORRECTIVE ACTION		
						DATE CORRECTED		
DN				DISCOVERED BY		CORRECTED BY		INSPECTED BY

AFTO FORM 781A

MAINTENANCE DISCREPANCY AND WORK DOCUMENT

PREVIOUS EDITION IS OBSOLETE

Figure 5-4. AFTO Form 781A.

Corrective Action block. The use of this block is self-explanatory. When a defect entered in the Discrepancy block opposite this block has been corrected, the action taken to accomplish the task is entered as briefly as possible in the Corrective Action block. There are few restrictions or requirements for these entries, but some do exist. For instance, when the corrective action requires technical references, torquing, operational checks or other verification, such will be entered in this block. If a discrepancy cannot be duplicated in that maintenance personnel are unable to make the equipment malfunction as described in the Discrepancy block, the facts are stated in the Corrective Action block. This entry will be entered only after the best qualified maintenance man has investigated the malfunction, to assure that all possible avenues have been pursued. One other important requirement is the unscheduled replacement of time change items. If this equipment is changed before the normal life cycle ends, this corrective action must be underlined in red for the benefit of the documentation personnel, who must post this information in the appropriate records.

When the corrective work has been done, this action must be attested to by the responsible technician. If the work is routine and does not require inspection, then the mechanic who accomplished the task must sign the Corrected By block and enter his grade and man-number. This same mechanic will then place his last name initial over the red symbol in the Discrepancy block. If the work requires final inspection because of the seriousness of the condition, then this final inspector's signature is placed in the Inspected By block, and it is his last name initial that is placed over the symbol. This second condition is shown in the fuel flow discrepancy given in figure 5-4.

When a new AFTO Form 781A is initiated, any uncorrected discrepancies other than red X items may be transferred to the AFTO Form 781K. The name of the individual who makes the initial entry in the AFTO Form 781A need not be retained with the discrepancy when the entry is transferred to the AFTO Form 781K, or carried forward to a new AFTO Form 781A. When a discrepancy is carried forward to a new AFTO Form 781A, the crew chief or his alternate must enter the page number, item number, the date of the new form, and place his signature and grade in the Transferred By block. If the discrepancy is to be transferred to the AFTO Form 781K, he will enter the date of the transfer

action and place his signature and grade in the Transferred By block. An initial should not be placed over the symbol for discrepancies that are carried forward or transferred to another form, since this only represents transcribing action and does not correct the reported condition. When a discrepancy is carried forward to a new AFTO Form 781A or is transferred to the AFTO Form 781K, the job control number, and if applicable, the supply document number and AFTO Form 350 tag number must be carried forward with the discrepancy.

Exercises (057):

1. Record the following information on the AFTO Form 781A provided in figure 5-5.
 - a. Aircraft type - C-130E
 - b. Serial number - 66-243
 - c. Organization - 516th Military Airlift Wing
 - d. Location - Dyess AFB Tex
 - e. Crew chief - SSgt S. Black
 - f. 781A start date - 19 March 1974
2. Record the following actions on the AFTO Form 781A on figure 5-5, using TO 1C-130A-06 in foldout 1.
 - a. 0200 hours, 19 March 1976, Sgt Black was preflighting his aircraft for a local mission and discovered the nose landing gear actuator leaking beyond limits.
 - b. 0230 hours, 19 March 1976 Sgt Black called the discrepancy into job control and received a job control number of 0787550.
 - c. 0300 hours, 19 March 1976, Sgt F. Smith and TSgt P. Jones arrived from the pneudraulic shop. They pressure checked the actuator and confirmed that it was leaking beyond limits.
 - d. 0330 hours, 19 March 1976, Sgt F. Smith ordered a new nose landing gear actuator, and received a supply document number of X103HS60780001.
 - e. 0530 hours, 19 March 1976, the actuator was removed and replaced. Sgt Smith corrected the discrepancy, and TSgt Jones performed the required inspections. Sgt Smith's man number is 4112, and the 350 tag number was 35320.

PAGE 1 OF 1 PAGES

DATE FROM		TO		CREW CHIEF		ORGN		LOCATION		MOS		SERIAL NO.	
				S. BLACK SLT									
SYM	DATE DISCO	WDC	JCN	TAG NO		CF TO 781A DATED		TRANSFERRED TO		TRANSFERRED BY			
						P 1		DATE					
DISCREPANCY						CORRECTIVE ACTION							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	
SYM	DATE DISCO	WDC	JCN	TAG NO		CF TO 781A DATED		TRANSFERRED TO		TRANSFERRED BY			
						P 1		DATE					
DISCREPANCY						CORRECTIVE ACTION							
DN				DISCOVERED BY				CORRECTED BY				INSPECTED BY	

AFTO FORM 781A MAY 73 MAINTENANCE DISCREPANCY AND WORK DOCUMENT

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Figure 5-5. Blank AFTO Form 781A (objective 057, exercises 1 and 2).

058. Clarify selected entries used on the AFTO Form 781K as to form and content.

AFTO Form 781K. This is called the Aerospace Vehicle Inspection, Engine Data, Calendar Item Inspection and Delayed Discrepancy Document. Look at this title closely and you will find that it encompasses every area covered on this form. Basically, it is used to record and keep track of inspections due or completed. Figure 5-6 depicts typical entries for this document. We will cover only block H of this form (TCTOs and delayed discrepancies), however, because it will be the main portion that you will be using.

Delayed discrepancies may be transferred from the AFTO Form 781A, or upon completion of scheduled maintenance, from the AFTO Form 349. Red X or circled red X entries will not be entered in this section of the AFTO Form 781K.

Figure 5-6 shows an example of entries that we will briefly explain. The Symbol block will reflect

the same symbol given the original discrepancy. TCTOs will usually be assigned a red diagonal until upgraded, as is the case of the urgent action TCTO, which is upgraded from a red diagonal to a circled red cross upon expiration of the time limit or when work starts. The Number and Publication Date or Discrepancy column is used to record titles and/or information about the entry. Note that our entries also include assigned job control numbers and supply document numbers. This kind of information is important during scheduled records checks and for other reference purposes. The Sys column references the aircraft system to which that discrepancy or entry pertains. System 11 from our sample represents "airframe general." This information is found in the dash 06 code manuals available in all maintenance areas. The date, time, and code columns are self-explanatory and are used to record that information at the time these entries were discovered.

The last two columns of this section are used only when these entries are transferred to another

H. URGENT ACTION AND OUTSTANDING ROUTINE ACTION TCTO AND DELAYED DISCREPANCIES							
SYM	TCTO NUMBER AND PUBLICATION DATE OR DISCREPANCY	SYS	WHEN DISC'D OR ENTERED			DATE TO AFTO 549 OR 781A OR DATE CW	TRANSFERRED BY OR COMP VERIFIED BY (Signature)
			DATE	ACFT TIME	CODE		
~~1~~	~~FLT STA FLUID DELAMINATED HOLD~~		~~11~~	~~22/11/3~~	~~91702~~	~~D~~	
~~2~~	~~FAR MAJOR INSR-326-8210~~		~~11~~	~~22/11/3~~	~~91702~~	~~D~~	
~~3~~	~~FLT TOWERS TUBE BEARING STUCK~~		~~11~~	~~22/11/3~~	~~91702~~	~~D~~	
~~4~~	~~RF WING STA 440-322-4015~~		~~11~~	~~22/11/3~~	~~91702~~	~~D~~	
~~5~~	~~240-322-8210~~	~~14~~	~~11~~	~~22/11/3~~	~~91702~~	~~D~~	~~D. Dickmuth~~

Figure 5-6. AFTO Form 781K.

document for action or are no longer open. At this time the mechanic accomplishing the action will date and sign in the Transferred By column. The entry will then be lined out except for the Date and Signature blocks, to indicate that the entry is closed out on this form.

Exercises (058):

1. Can a red X item be entered in block H of the 781K?
2. To indicate that a delayed discrepancy has been cleared, what should be done?
3. What does the System column of the 781K reference?
4. Why are job control numbers and supply document numbers entered in the Discrepancy column?

059. Determine the meaning of selected given aircraft data entries on the AFTO Form 781H, using the 781H in figure 5-7.

AFTO Form 781H. The majority of AFTO 781 series entries are made on the forms just discussed and the form we are about to cover, the AFTO Form 781H, Aerospace Vehicle Flight Status and Maintenance Document, shown in figure 5-7. Just as the title suggests, this form depicts the current status of the aircraft and serves as a ready reference to the servicing, maintenance and inspection

history. Only main blocks that will concern you as a pneudraulic specialist—blocks 9, 10, 11, and 14—will be mentioned.

Block 9. The Status Data block is divided into three sections, i.e., Status Today, Box No., and Exceptional Release. The Status Today portion is itself divided into boxes numbered from 1 through 12. At initiation of this form, the last status symbol of the previous form is brought forward to box 1 of the new form. If no defects exist on the aircraft, the last name initial of the crew chief, or whoever performs the preflight inspection, is entered in box 1. The status symbol recorded in these boxes will always represent the most serious condition in block 7, noted in the AFTO Forms 781A and 781K. When status changes occur during the day, the next open box is used to record the applicable symbol. Symbol entries recorded in these boxes are never erased, initialed over, or changed within any given box, even if entered in error. Any symbol entered in error is explained by an entry on AFTO Form 781A before you enter a new, correct status symbol in the next open box.

The Box No. and Exceptional Release blocks are two very important sections of this form. It is at this point that the maintenance officer or his representatives make a major contribution to forms and maintenance management. It is important that maintenance managers realize the significance of this entry. The Box No. block is used to denote which symbol of the Status Today column is being signed for. The number entered here is the responsibility of the person signing the Exceptional Release column.

The Exceptional Release column is used for the signature of the person who releases the aircraft for flight. This release is required before flight when a red dash or red diagonal appears as the last entry in the Status Today columns. Under no circumstances will the exceptional release be granted when the aircraft status is indicated by a red X or circled red X symbol. The exceptional

1. DATE 10/01/4		2. CREW CHIEF C. Padgett SSgt		3. ORGANIZATION 437 MAW		4. LOCATION CHARLSTON AFB S.C.		5. MDS C-141A		6. SERIAL NUMBER 66-230	
7. STATUS OF OVERDUE INSPECTIONS AND ACCOMPLISHED INSPECTIONS INCLUDING 781A						8. CERTIFICATION FOR ACCOMPLISHMENT OF BASIC POSTFLIGHT OR THROUGHFLIGHT					
TYPE	STA	SYSTEM	ACCOMPLISHED BY	COMPLETED DATE TIME		FLT NO	TYPE INSP	ACCOMPLISHED BY	COMPLETED DATE TIME		
PR	P	OS(ACFT & ENG)	C. PADGETT SSgt	10/01/4 09:30		1	BPO	B. HUDSON SSgt	10/01/4 14:20		
				/ / :		2			/ / :		
				/ / :		3			/ / :		
				/ / :		4			/ / :		
				/ / :		5			/ / :		
				/ / :		6			/ / :		

9. STATUS DATA				10. FLIGHT CONDITION DATA							
STATUS TODAY	BOX NO	EXCEPTIONAL RELEASE (Enter Box No.)		FLT NO	COND APT FLT	PILOT'S SIGNATURE ENTER AFTER EACH FLIGHT				Over Temp Enclrd	Aux Engine or APU Operation
1	3	C.A. LOHMAN 2LT (MO)		1							
2				2							
3				3							
4	10			4							
5	11			5							
6	12			6							

11. MUNITIONS/GUNS STATUS		STATUS	H	C	N	H	C	N	H	C	N	H	C	N	H	C	N	TOTAL TODAY
781A ENTRY		P	I		P	I		P	I		P	I		P	I		P	I

12. SERVICING DATA																	
FUEL (Gallons or Pounds)			ENG				OIL (Gms, Quarts, or Gallons)				CSD				OXY PRESS OR QTY	APV	
SER NO	OCTANE OR GRADE	QUANTITY SERVICED	TOTAL IN TANKS	1	2	3	4	1	2	3	4	1	2	3			4
1	JP-4	—	70,000	0 24	0 24	0 24	0 24	0 10	0 10	0 10	0 10	0 10	0 10	0 10	0 10	100	4
2	JP-4	20,000	90,000	0 24	0 24	0 24	0 24	0 10	0 10	0 10	0 10	0 10	0 10	0 10	0 10	100	4
3																	
4																	
5																	
6																	

13. SERVICING CERTIFICATION (Signature, Grade and Station at Which Servicing is Accomplished)											
1	BY	J. Anderson 1st Lt	3	BY		5	BY				
	AT	Charleston AFB		AT			AT				
3	BY	J. Anderson 1st Lt	4	BY		6	BY				
	AT	Charleston AFB		AT			AT				

14. AIRFRAME TIME		15. LANDINGS		16. CARTRIDGE STARTS		17. ENGINE CYCLE DOCUMENTATION							
PREVIOUS	92745	FULL STOP	TOTAL	NO. ENG.	NO. ENG.	NO. 1 ENG.	NO. 2 ENG.	NO. 3 ENG.	NO. 4 ENG.	NO. 5 ENG.	NO. 6 ENG.	NO. 7 ENG.	NO. 8 ENG.
1	6.5	1	3			3	3	3	3				
2													
3													
4													
5													
6													
TOTAL	92810	2167	8407										

AFTO FORM 781H
MAY 78
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U.S. Government Printing Office: 1973 - 750-788/7018 Region 5-11

AEROSPACE VEHICLE FLIGHT STATUS AND MAINTENANCE DOCUMENT

Figure 5-7. AFTO Form 781H.

release is a certification that the authorized individual who enters his signature in this column has investigated defects covered by red symbols and that, in his opinion, the aircraft is safe for flight.

An exceptional release may be granted as a conditional release. For example, the release of an aircraft with defective night flying equipment may include the condition that the aircraft is not to be flown during hours of darkness. When such conditional releases are granted, the conditions of the release will be described by an appropriate entry in the AFTO Form 781A.

Block 10. The Flight Condition Data block is divided into five sections, with provisions for six line entries. This block is used for the pilot to make entries after a flight. If the flight was satisfactory, with no discrepancies, he enters OK in the Cond Aft Flt column. If there were discrepancies, he enters the number of discrepancies in this column. Each discrepancy encountered will also be entered in the AFTO Form 781A.

Block 11. The Munitions/Guns Status blocks or lines are used to record armament status. The status portion is used to indicate whether or not the munitions are hot, cold, or not installed by circling the appropriate symbol in red. The 781A Entry block is used to indicate the page (P) and item (I) in the AFTO Form 781A where this armament configuration is explained. This 781A entry is cleared either by the pilot or the munitions loading chief, depending upon whether the munitions were all expended in flight or were down-loaded after landing.

Block 14. The Airframe Time block is simply a continuous record of flying hours. Six lines are provided to record the number of flights for 1 day. The previous block reflects the total flying hours since the aircraft was new. The crew chief or his representative usually transcribes the flying time from the AFTO Form 781 to this form during the debriefing session and enters the sum of these figures in the Total block. This total is then transcribed to the previous block of the new AFTO Form 781H.

Exercises (059):

Using the AFTO Form 781H shown in figure 5-7, determine the meaning of various entries as follows:

1. What does it mean when a black last name initial is placed in box 1 of block 9?
2. What should be done if an entry is entered in error?

3. What is indicated if a red X is placed in the last open box of block 9?
4. Can an exceptional release be granted for a red X or circled red X?
5. What does it indicate if a pilot places an OK in the Cond Aft Flt column of block 10?
6. What does it mean if a red circle is placed around the word "Hot" in block 11?
7. You get the total aircraft time. Which block would you go to for this?

060. Define the word "cannibalization" and describe briefly the routing and entries made on the AF Form 991.

Here we discuss, first, "cannibalization" and, second, the AF Form 991.

"Cannibalization"—What Is It? Cannibalization is the authorized removal of a part from one weapon system or equipment end item, for installation on another similar piece of equipment or end item, to meet mission priority requirements. In other words "rob one aircraft to fix another." However, a demand should be made on the supply system before resorting to the cannibalization action in order that proper stock leveling can be established for future requirements. Cannibalizations require expending a higher number of maintenance man-hours to correct a discrepancy; therefore, the number of cannibalization actions must be carefully controlled. That is why only the deputy commander for maintenance or his designated representative will authorize cannibalization actions. AF Form 991 (record of cannibalization) is used to record cannibalization actions along with AFTO Form 349.

AF Form 991. Figure 5-8 shows sample entries on the AF Form 991. If you will notice, the form is broken down into three sections: (1) Materiel Control, (2) Maintenance Control, and (3) Record of Cannibalization Action. To insure accurate documentation of cannibalization actions, close coordination is required from each section involved.

RECORD OF CANNIBALIZATION				
MATERIEL CONTROL				
NOON	VALVE	STOCK NUMBER	WORK UNIT CODE	
		1650-670-1388	46821	
P	M/O/S	SERIAL NUMBER	OWNING ORGANIZATION	
0	KC-135A	55-3139	17 BWG (SAC)	
DATE/HOUR REQUIRED		PART REQUESTED BY	SUPPLY DOCUMENT NUMBER	
15/04/3 1100		R. Chastain, SSgt	X2431X21710151	
DATE/TIME		THE REQUIRED PART WILL NOT BE AVAILABLE ON TIME. CANNIBALIZATION RECOMMENDED (Signature - Materiel Control Officer)		
15/04/5 1000		Thomas H. Dunn Jr. CMSgt		
MAINTENANCE CONTROL				
RECOMMEND CANNIBALIZE FROM		M/O/S	SERIAL NUMBER	
		KC-135A	57-1425	
OWNING ORGANIZATION		TIME CHANGE ITEM SER. NO.	PREV. OPER. HOURS	
17 BWG (SAC)		NA	NA	
EST. HOURS REQUIRED FOR	MAN HOURS	CLOCK HOURS	OPER. HOURS TO GO	
REMOVE AND REPLACE	2.0	1.0		
REINSTALLATION	1.0	.5		
DATE/TIME		SIGNATURE MAINTENANCE CONTROL OFFICER		
15/04/5 1015		Robert L. Fishback, MAJ.		
DATE/TIME		RECOMMENDED CANNIBALIZATION IS AUTHORIZED (Signature - Chief of Maintenance)		
15/04/5 1030		Charles R. Hurst, Lt. Col.		
RECORD OF CANNIBALIZATION ACTION (Action Personnel Sign in Respective Space Below)				
BY	REMOVE AND REPLACE	DATE	INSTALLATION	DATE
MECHANICOR SPECIALIST	Copy 1 J. McComister, Sgt	15/04/5	Copy 2 Ray Hergoy, AIC	27/04/5
MAINTENANCE CONTROL	Copy 1 and 2 Harry Naylor, Capt	15/04/5	Copy 2 Tom Clark, 2 nd Lt	27/04/5
RECORDS	Copy 1 Bruce Yarnin, 1st Sgt	15/04/5	Copy 2 B. Coffin, MSgt	27/04/5
MATERIEL SECTION	Copy 2 and 3 C. Woodward, MSgt	15/04/5	Copy 2 H. Hammer, SMSgt	27/04/5

AF FORM 991
NOV 67

PREVIOUS EDITION WILL BE USED

GPO: 1971 O - 422-697

Figure 5-8. AF Form 991.

Materiel Control section. When the need for cannibalization of a part is recommended, the AF Form 991 is initiated in three copies by MSL (maintenance Supply Liaison) personnel. They will fill out the Materiel Control section, which is self-explanatory. The three copies are then sent to maintenance control.

Maintenance Control section. The job control section of maintenance control will decide whether or not the cannibalization action should be taken. If so, it then selects the weapon system or equipment end item that will be cannibalized. Next, job control personnel will complete the Maintenance Control section of the AF Form 991, which is also self-explanatory. Thereafter they send it to the Deputy Commander for Maintenance or his designated representative, who will enter the date, time, and his signature in the appropriate block. Once the deputy commander for maintenance has signed the AF Form 991s, copy 3 goes to MSL, copy 2 is kept by maintenance control, and copy 1 is sent to the work center assigned primary responsibility for the cannibalization action.

Record of Cannibalization Action section. The mechanic or specialist completing the action will enter his signature, grade, and date in the Remove and Replace column of the AF Form 991. From the work center, it is sent back to maintenance control, which will transcribe the information from copy 1 onto copy 2. Following this, maintenance control personnel will complete the Remove and Replace portion of both copy 1 and copy 2. Next, copy 1 is sent to the appropriate documentation activity. Copy 2 is sent to MSL, where they will transcribe the information onto copy 3 and complete the Material Section of the Remove and Replace column. Then copy 3 will be sent to supply management, and copy 2 will be kept at MSL until the cannibalized part arrives.

After Receipt of the Replacement Part. When notified by supply that a replacement part has arrived, MSL personnel will remove the AF Form 991, copy 2, from the suspense file and complete the Materiel Control line, under the Installation column. They will then forward this copy to maintenance control, which will take action to have the item installed. Next, the Maintenance Control line under the Installation column will be completed. Thereafter it will be sent to the primary work center for action. The primary work center personnel will install the new item and complete the Mechanic or Specialist line under the Installation column. Following this, copy 2 will be sent to the documentation activity, which will update the affected equipment documents. After they have updated the documents, they will complete the Records line under the Installation column. Copy 2 of AF Form 991 will be filed in the historical file of the equipment from which the item was removed.

Exercises (060):

1. Simply speaking, what does the word "cannibalization" mean in reference to the maintenance complex?
2. How many AF Forms 991 does MSL initiate?
3. Which unit decides what aircraft an item should be cannibalized from?
4. Where is copy 2 of the AF Form 991 kept until the replacement part comes in to replace a cannibalized item?
5. How do you, the pneudraulic specialist, indicate on the AF Form 991 that an item is installed on the aircraft?

061. Clarify the AFTO Forms 443 and 444 by giving their purposes and discussing selected entries recorded on them.

In this LO our focus will be on the AFTO Forms 443 and 444.

AFTO Form 443. The AFTO Form 443 is the Trainer/AGE Status and Operating Record. This AFTO form is used to provide the operator and the repairman with a record of the current status of the unit. A sample AFTO Form 443 is shown in figure 5-9. Study this figure as we proceed.

Begin your review of the maintenance AFTO Form 443 by checking its Part I. This part is the identification record and contains seven blocks of information. The first block in Part I is the Date block. Here the date must be entered when the form was started and when the form is closed out.

Blocks 2 and 3 identify the end item by its nomenclature and type of model. Enter in block 2 the name of the end item, such as air compressor or generator set. Enter in block 3 the type or model of the end item, such as MD-3M or MC2A. This information must clearly identify the end item.

In block 4 of both forms you would enter the end item registration number. The end item registration number is stenciled on the side of the unit, and this is usually the number used to fill in block 4.

The work unit code is entered in block 5. This code is found in the -06 code manual for AGE, and

AFTO FORM 443
JUN 72

REPLACES AFPO FORMS 45 AND 83,
WHICH ARE OBSOLETE.

Figure 5-9. AFTO Form 443.

it aids the repairman in finding the subcodes needed for his maintenance forms.

If the incorrect work unit code and subcodes are used on the maintenance forms, you'll have errors in the maintenance data collection system. This, in turn, will give AFLC incorrect information in the maintenance data statistical reports. Therefore, it is necessary that the correct work unit code be used on all maintenance forms.

Enter the ID/serial number in block 6. The ID number is a locally assigned number. The ID number is used on all AFTO Forms 349 and 350 for maintenance actions against the unit.

In block 7 enter the designation of the owning organization of the equipment. Part II, Inspection Record, is used to record due and accomplished scheduled inspections. This section is important to the mechanic in determining condition status. The Inspection Due column should be examined to assure that inspections are, in fact, still due rather than overdue.

Part III of the AFTO Form 443 is the Service Inspection and Status Record. The Status Today column should reflect the current status of the unit. In checking the forms, the status today symbol should correlate with the most serious uncleared discrepancy in Part II of the AFTO Form 444, which will be discussed next.

AFTO Form 444. The AFTO Form 444, shown in figure 5-10, is the Trainer/AGE Maintenance Record. It is used to provide a continuous record of all maintenance, both minor and major, that has been completed on the unit. It also provides a record of any uncleared discrepancies that may affect unit operation. The form consists of three sections. Part I, Item Identification Record, is identical to Part I of the AFTO Form 443. Part II, Maintenance Record, is the section of the form pertinent to the flight-line mechanic. It is this section into which entries are made by the user as they are discovered. The discrepancy in the Symbol block should agree with the Status Today column of the AFTO Form 443.

Suppose a unit were dispatched to the flight line with a red X entered in Part II of the AFTO Form 444 but not in Part II of the AFTO Form 443. Then a flight-line mechanic, who is in a hurry, casually glances at the AFTO Form 443. He doesn't realize that the unit is on a red X; so he tries to start it. Immediately things will begin to happen—the unit may even come apart or start a fire. Either result can cause injury to the mechanic or the possible loss of a million dollar aircraft. Therefore, it is important that you correlate the status symbols between the two forms.

From the information which we have discussed in the previous objective of this course, Part II—Maintenance Record should be self-explanatory. To show you how simple this form is to use, we will simulate a situation in which you might become

involved. Let's say that you have been operating a hydraulic test stand, and it develops a large hydraulic leak. Look at figure 5-10 while we talk about placing an entry on the forms. Under the Date Discovered column, enter the date the discrepancy was discovered. Under the Discovered By column, enter your name and rank. Under the Symbol column, enter the symbol which you believe is appropriate for this type of discrepancy. Under "When Disc. Code," enter the code used to indicate when the item was discovered. This code can be found in the -06 work unit code manuals. Then in the Discrepancy column, enter the discrepancy. In this case the discrepancy would read something like this: Large hydraulic leak from pump pressure line to gage (give approximate vicinity of leak if you can find it).

When an AFTO Form 443 or 444 has any one of its sections completely filled, the record is closed out. This is done by completing the date in TO block in Part I, Item Identification Record. A new form is initiated at that time, and any uncleared discrepancies are entered on the new form. The old form is then placed in the historical records, and retained as a permanent part of the equipment records.

Exercises (061):

1. What is the purpose of the AFTO Form 443?
2. In what portion of the AFTO Form 443 would you look to find out the condition of the equipment?
3. What purpose does the AFTO Form 444 serve?
4. If you found a discrepancy on a piece of equipment, what would be the minimum entries placed on Part II of the AFTO Form 444?

062. Concerning the materiel deficiency reporting system, state its purpose and, given hypothetical situations, identify the report category in each such situation.

Materiel Deficiency Report. The purpose of the materiel deficiency reporting system is to provide data to activities who are responsible for development, procurement, and other logistics management functions. If warranted, this data is then used to initiate action to correct materiel

PART I - ITEM IDENTIFICATION RECORD															
1. FROM DATE		2. NOMENCLATURE		3. TYPE/MODEL		4. REGISTRATION/SERIAL NO		5. WORK UNIT CODE		6. I.D./SERIAL NO		7. ORGANIZATION			
31	10/3			GAS TURBINE COMP.		MAIA		2835 56 DEF		AQ 300		AGT 166		1 TFS	

[illegible]

REPLACES PART IV, AFHQ FORMS 45 AND 49, WHICH ARE OBSOLETE.

TRAINER/AGE MAINTENANCE RECORD

Figure 5-10. AFTO Form 444.

design and prevent quality deficiencies. In other words, included here are those materials which do not conform with applicable specifications, drawings, standards, etc. Also, included here are errors in workmanship either during manufacture, repair, modification, or maintenance.

The maintenance data collection system is the primary source of data. It is therefore the principle source of materiel deficiency information.

Step-by-step procedures and instructions for reporting materiel deficiencies are outlined in TO 00-35D-54, *USAF Materiel Deficiency Reporting and Investigating System*. This TO should be consulted whenever questions arise concerning materiel deficiency reports.

Reporting procedures are broken down into two categories: Category I and category II reports.

Category I Reports. Category I reports are concerned with emergency conditions pertaining to safety on all types of equipment. Emergency conditions are defined as:

a. Accident or incident—any event that does damage, or could cause damage, to persons or property, excluding enemy action.

b. Nuclear safety deficiency—any deficiency which could cause, or contribute to, a nuclear accident or incident.

c. Critical safety deficiency—the malfunction of a part, component, or installation which creates a hazard that must be corrected as soon as possible for personnel and systems survival.

d. For aircraft—any materiel or installation deficiency which requires inflight emergency procedures to avert further damage or injury to personnel.

Other conditions are described in TO 00-35D-54.

Category I reports are submitted by electrical transmission to Air Logistics Command (ALC), where they generate investigation projects. These projects are given the highest priority available. Category I reports require continuous (around the clock) action for a solution.

Category II reports. These reports are used to report design and maintenance materiel deficiencies of non-work-coded items. These deficiencies do not have a safety impact, but if left uncorrected they could:

a. Create a safety hazard.

b. Have a negative effect on operational effectiveness.

c. Reduce tactical or tactical supportability.

d. Reduce operational life or general service utilization of equipment.

e. Create economic burdens (both manpower and money).

Category 'I' reports are submitted to ALC by automatic digital network (AUTODIN). Other

materials, such as photographs, go by airmail. These reports receive a lower priority investigation than do priority I reports.

The person discovering the deficiency will prepare, process, and route materiel deficiency reports as prescribed in TO 00-35D-54. The Deputy Commander for Maintenance of the submitting activity will review all materiel deficiency reports prior to submittal to insure that they are reported correctly and properly routed. The safety office should also be informed of accidents or incidents where damage or injury results from materiel deficiencies.

Materiel deficiency exhibits. Materiel deficiency exhibits will be held by quality control (or base supply when storage facilities are not available) or as designated by the major command. Storage should be a secure, minimum-access—preferably locked—area to insure that the exhibit is not altered or lost. Exhibits, if shipped, should go by priority methods, such as airlift, airmail, or express.

NOTE: Under no condition will any disassembly or repair be accomplished on the exhibit by field activities. When directed the item will be forwarded in the exact condition as it was when found deficient. All exhibits will be identified with an AFTO Form 114, Materiel Deficiency Exhibit Tag, attached to the exhibit, and also to the outside of the container near the address label. For this, see figure 5-11.

Exercises (062):

1. While inspecting the aileron control system during the acceptance inspection of a new aircraft, you discover that the aileron will not go to the full up position. Further investigation reveals that the aileron control valve binds because the mount bracket is not positioned properly. Which materiel deficiency report category would be used to report this condition? Explain why briefly.
2. Which category deficiency report would be submitted to correct a condition on an aircraft which would not involve personnel or equipment safety?
3. Which tag will be attached to a materiel deficiency exhibit?
4. What is the purpose of the materiel deficiency reporting system?

MATERIEL DEFICIENCY EXHIBIT

1. Report Control Number.	2. Date	3. Originating Activity
6. Remarks; (Continue on Reverse Side)		4. Stock and Part No. Item Description
		5. Signature

AFTO FORM 114
FEB 72

PREVIOUS EDITION WILL BE USED

FRONT

MATERIEL DEFICIENCY EXHIBIT

7. Date Released	8. Released To:
9. Remarks Continued:	

BACK

Figure 5-11. AFTO Form 114, Materiel Deficiency Exhibit Tag.

Maintenance Management and Supervision

AIR FORCE MAINTENANCE responsibilities are of such a magnitude that it demands streamlined management and strict attention to detail. In this chapter you will learn the makeup of a maintenance management organization. We will then break down each aspect of the maintenance management organization and talk briefly about each. Later in the chapter you will assume the position of a shop supervisor and look at his responsibilities, employee relations, and production. Also, you will study the organizational and functional charts so important to visually present organizational structure, and mission.

6-1. Maintenance Management

The Air Force is one of the largest organizations in the world. Just as any business, whether large or small, it has to be organized in order to be successful. Without management, the job may get done, but is it done properly, on time, and with the proper manpower and equipment? The efficient use of this manpower and equipment is the responsibility of management personnel. Air Force Manual 66-1 establishes the maintenance management system, which is used by all Air Force activities engaged in maintenance. All Air Force personnel must be trained in the use of the maintenance management system to facilitate the timely accomplishment of the Air Force Mission.

063. Examine the Air Force maintenance management system by citing the chain of command from the President to the pneudraulic shop and associating each major command with its purpose.

Here we take up, in sequence, the chain of command, the organization of the Air Force, and the major commands.

Chain of Command. Looking at figure 6-1, observe that it shows the chain of command from the President of the United States to the pneudraulic shop. The President is the Commander in Chief of the Armed Forces (Army, Navy, Air

Force, etc.). His chief adviser is the Secretary of Defense, who is a civilian charged with administration of the Department of Defense (DOD) activities.

Organization of the Air Force. The Secretary of the Air Force is the civilian head of the Air Force. He is directly responsible to the Secretary of Defense. The Air Force Chief of Staff is the chief military leader for the Air Force. The Secretary of the Air Force and the Air Force Chief of Staff direct the activities under them from the Pentagon (Headquarters USAF). This is the nerve center for the major commands around the globe.

Major Commands. Our Air Force is divided into major commands, each one of which has a definite mission. The missions are divided into three broad areas: combat, support, and overseas.

Combat commands. The major commands are as follows:

a. **Aerospace Defense Command (ADC).** As its name implies, this command is charged with our country's air and space defense. It maintains a capability to meet any direct attack. ADC headquarters is at Colorado Springs, Colorado.

b. **Strategic Air Command (SAC).** This command maintains offensive capability to strike at key targets in enemy territory. The SAC force of bombers and missiles is used as a deterrent; that is, it helps discourage attacks by potential enemies. SAC headquarters is at Omaha, Nebraska.

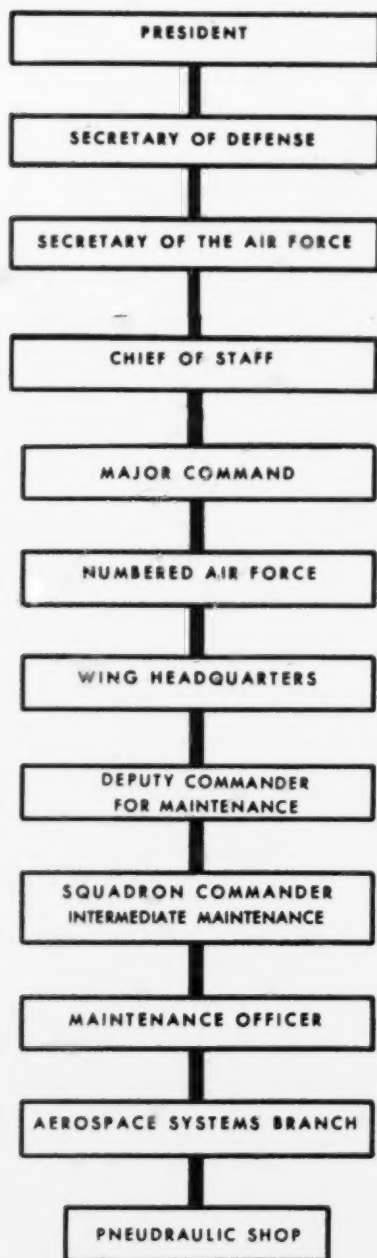
c. **Tactical Air Command (TAC).** This command conducts air operations in support of land and naval forces. It may directly support troops in the field. TAC headquarters is at Langley AFB, Virginia.

Support commands. These are the support commands:

a. **Air Training Command (ATC).** This command provides training for the various major commands.

b. **Military Airlift Command (MAC).** It is this command's mission to transport cargo and troops.

c. **Air Force Logistics Command (AFLC).** Logistic (supply) support is provided to the Air Force's aerospace weapon systems by this command.



42-337

Figure 6-1. Chain of command.

d. Air Force Systems Command (AFSC). AFSC performs research, testing, and evaluation for advancing aerospace technology.

Overseas command. Many commands are located overseas, and because of their unique

locations, they are not placed in the same class as the commands already listed, but are, instead, merely named. They are:

- a. United States Air Force in Europe (USAFE).
- b. Pacific Air Forces (PACAF).
- c. Alaskan Air Command (AAC).
- d. United States Air Forces Southern Command (USAFSO).

The above listed major commands are not all inclusive; in fact, you may be in another command which has not been listed here. Nevertheless, we have given here those commands which we feel you will come in contact with most often.

Organization from major command level to unit level may vary in detail with different major commands. Thus, some major commands have numbered air forces, while others do not. Next in the chain of command comes wing headquarters. The wing integrates all of the elements needed for performing a mission and operating a base.

Wing headquarters. Under wing headquarters, the head of the maintenance program is the Deputy Commander for Maintenance (DCM). This is usually the senior maintenance officer in the organization. Later on in this chapter we will talk more about the DCM and his staff. Immediately under the DCM come the squadron commanders. Because the squadron commander deals with many other subjects besides maintenance, he has assigned a maintenance officer who provides overall direction for maintenance performed in that squadron. Directly under the maintenance officer come the maintenance branches. The aerospace systems branch is a typical branch found in a field maintenance (intermediate) squadron. As a pneudraulic mechanic, you may be assigned to a pneudraulic shop operating under the aerospace systems branch. You should take the time and effort to know each position, and the name of each person holding that position in your squadron's chain of command.

Exercises (063):

1. Who is the Commander in Chief of the Armed Forces?
2. List the chain of command from the President to the pneudraulic shop.
3. Match each mission given in column B with its related major command(s), found in column A, by putting each numbered mission (column B) beside its corresponding major command (column A). NOTE: Each item in column B may be used once or more than once.

Column A Major Commands	Column B Missions
— a. SAC.	1. Combat.
— b. MAC.	2. Support.
— c. USAFE.	3. Overseas.
— d. TAC.	
— e. AFLC.	

064. Clarify the maintenance levels by associating each level with the type(s) of maintenance it performs and specifying the main maintenance inspection concepts and what specified inspections accomplish.

First, the levels of maintenance; then, in order, inspection concepts, and other common inspections concern us here.

Levels of Maintenance. Since your job concerns maintenance, you should know the three levels of maintenance. The three levels of maintenance we discuss in the following paragraphs are: organizational, intermediate, and depot. You are, or probably will be, assigned to a base or other organization which falls under one of these levels of maintenance.

Organizational maintenance. Maintenance at this level consists primarily of inspections, servicing, and preventive maintenance. This is, basically, a removal and replacement type of operation. Minor repairs and technical order modifications will depend upon the facilities available at the organizational level maintenance requirements will be. They will vary from base to base, depending upon the workload, skills, and size of the shop involved.

Intermediate maintenance. At this level you are required to perform maintenance beyond the capabilities of organizational level maintenance. This level of maintenance specializes in technical and equipment support. The support provided by intermediate maintenance consists primarily of furnishing specialist assistance to organizational level maintenance. Besides this, intermediate maintenance performs bench checks and repair within the capabilities of the personnel and equipment assigned. When intermediate maintenance capabilities are exceeded, the problem then becomes a matter for depot maintenance.

Depot maintenance. This highest level of maintenance requires extensive fixed and specialized equipment to perform major repair and overhaul. At depot overhaul, all systems are "inspected and repaired as necessary" (IRAN).

The chief function of a depot is to perform major modifications and overhaul of equipment and components beyond the capabilities of either the organizational or intermediate levels of maintenance. Depots also supply spare parts, aerospace ground equipment, and TOC (technical

order compliance) kits to the organizational and intermediate units through normal supply channels.

Inspection Concepts. The primary purpose of inspections systems is to prevent major problems before they arise. Preventive maintenance is an important aspect of the system. Discrepancies are detected and repaired before they cause equipment failures. Three authorized inspection concepts are used by the Air Force: periodic, phased, and isochronal.

Periodic inspection. The periodic inspection is a thorough and searching inspection of the entire aircraft. The inspection consists primarily of checking certain components, areas, and systems of the aircraft to determine that no condition exists which could result in failure of a component or cause a system to malfunction prior to the next scheduled inspection. The periodic inspection is considered due when the required number of flying hours have been accumulated.

Phased inspection. This inspection includes the consolidation of the basic postflight and/or hourly postflight, and periodic inspection requirements into small packages with approximately the same work content. This involves approximately the same number of clock hours. The primary objective of the phased inspection is to reduce the length of time that an aircraft is out of commission for any given scheduled inspection.

Isochronal (I-Sock-Ren-L) inspection. The isochronal concept is designed to translate flying-hour utilization rates into calendar periods, usually expressed in days. The scheduling program should be constructed to allow for the time that an aircraft is programmed to be in inspection status. For example, if an aircraft is scheduled to be in inspection status for 3 days, and the calendar inspection period (based on the utilization rate) is 70 days, the inspection should be scheduled each 73 days.

Other Common Inspections. Although the phased, periodic, and isochronal are the three authorized inspection concepts, there are other common inspections that you should be aware of.

Preflight inspection. This inspection is basically a flight preparedness check. The inspection consists of checking the aircraft by performing visual and operational checks. This assures that no defects or malfunctions exist.

Thruflight inspection. This inspection is a between-flights inspection. Basically, it is accomplished after each flight, if an immediate continuation flight is scheduled. The inspection consists of checking the aircraft for defects that would prevent it from making the scheduled mission.

Basic postflight inspection. This inspection is accomplished after the last flight of the flying period. This inspection is a more thorough check

than is either the preflight or the thruflight. It consists of visual and operational checks of the aircraft to assure that no defects exist that would be detrimental to flight.

Exercises (064):

1. Match each maintenance level found in column B with its related types of maintenance given in column A, by writing each numbered level (column B) beside its corresponding maintenance types (column A). NOTE: Each item in column B may be used once or more than once.

Column A Types of Maintenance Performed	Column B Levels of Maintenance
— a. Performs major overhaul.	1. Organizational maintenance.
— b. Services aircraft with fuel and oil.	2. Intermediate maintenance.
— c. Performs maintenance above intermediate level capabilities.	3. Depot maintenance.
— d. Performs routine inspections of aircraft.	
— e. Provides specialist and equipment support.	

2. What are the three authorized maintenance inspection concepts?
3. Which of the three authorized maintenance inspection concepts is a thorough and searching inspection?

4. Which inspection is accomplished after a required number of flying hours have been accumulated?

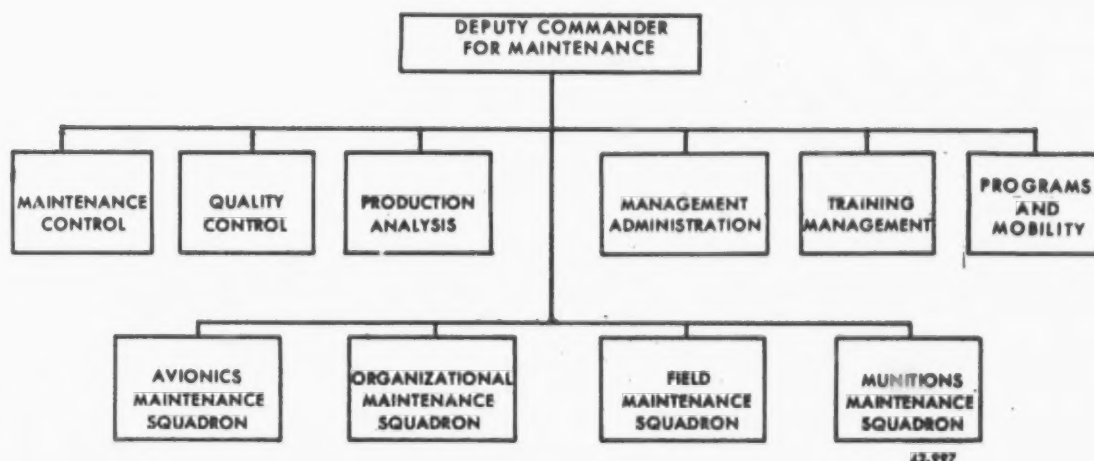
5. What is the primary objective of the phased inspection concept?

6. What type of inspection will be accomplished on an aircraft if it has just landed but is scheduled to take off again shortly?

065. Examine the Deputy Commander for Maintenance by identifying who he may be, his functions, and the agencies under him and select duties and responsibilities applicable to the DCM from a list.

Maintenance is a vital part of the organizational structure of the Air Force. In figure 6-2, you can see how each agency fits into that structure. Let's discuss each agency as well and its responsibilities. Beginning with the Deputy Commander for Maintenance we'll work our way down through these important staff agencies.

Deputy Commander for Maintenance. The job of Deputy Commander for Maintenance (DCM) is comparable to that of vice president of engineering for a large corporation. He must be highly qualified in leadership, management, and administration, because the aircraft maintenance organization of one wing is larger and more complex than the



42-997

Figure 6-2. Staff agencies of Deputy Commander for Maintenance.

operation of many commercial companies. The Deputy Commander for Maintenance is a position established at the highest level of operational control, and the person who occupies this position is usually the senior, and is always the most qualified, maintenance officer in the organization. He is the executive manager of his maintenance organization and exercises centralized control and direction of all functions of the activity.

Through the staff agencies provided for his use as assistants, the DCM manages, plans, controls, executes, and produces the work needed to fulfill his functional responsibility. The staff agencies act in the name of the Deputy Commander for Maintenance on those matters for which they have been given responsibility. He and his staff must provide the direction and guidance essential for all subordinates to implement, apply, and comply with local and higher headquarters directives.

Six staff agencies (commonly referred to as "branches") exist directly under the Deputy Commander for Maintenance that are common to most maintenance organizations. These branches, shown in figure 6-2, are:

- Maintenance control
- Quality control.
- Production analysis.
- Administration
- Training management.
- Programs and mobility.

Though not limited to these, the responsibilities of the Deputy Commander for Maintenance are to:

1. Insure that organizational and intermediate level maintenance performed on assigned equipment is timely and of high quality.
2. Provide the necessary direction and guidance for implementing maintenance policies and procedures.
3. Delegate that authority necessary for staff and production activities to perform assigned responsibilities.
4. Control the assignment and use of all available maintenance personnel. He coordinates with the servicing consolidated base personnel office (CBPO) and with the servicing central civilian personnel office (CCPO) for maintenance personnel requirements.
5. Insure conformance with laws, regulations, and policies pertaining to personnel assigned to the maintenance complex.
6. Coordinate with operations activities in establishing maintenance support requirements.
7. Insure that requirements necessary to support the maintenance mission are included in appropriate plans, programs, and host-tenant agreements.
8. Control the assignment and use of allocated maintenance facilities. He submits necessary documentation to appropriate agencies for new

construction and modifications or alterations to existing facilities, as required.

9. Insure that effective safety programs are established throughout the maintenance complex based on the AF 122 (on nuclear safety) and 127 series (on safety) publications.

10. Establish a utilities conservation program.

11. Insure that sufficient personnel are designated and available to clear red X conditions in all functional areas.

12. Manage the financial program within the maintenance complex.

13. Insure that a comprehensive training program is established throughout the maintenance complex.

14. Insure that engineering and technical service (ETS) personnel are effectively used in the maintenance training program.

15. Insure compliance with civil service commission and Air Force 40 series directives which deal with the promotion, training, and testing of civil service employees.

16. Insure that the briefing of each newly assigned maintenance officer and key supervisor includes the mission and structure of the organization and the scope of his responsibilities.

The scope of the overall responsibilities of the deputy commander for maintenance is such that some of them are handled by a group of staff agencies or sections. As we have mentioned earlier, the deputy commander for maintenance and his staff must plan, control, execute, and produce as effective managers to direct and guide subordinate activities in the accomplishment of the assigned mission. The supervisors of these agencies are on his staff to furnish him with the technical support, data, and coordination required for effective management of the activity. They take the responsibilities for certain control functions which are common to all maintenance activities, each agency being responsible for certain functions that are related and dependent on each other.

Exercises (065):

1. Usually, who is the Deputy Commander for Maintenance?
2. State the six staff agencies that work for the Deputy Commander for Maintenance.
3. Explain briefly the overall function of the deputy commander for maintenance.

4. From the following list of duties and responsibilities, indicate, by placing an X in the space provided, those duties and responsibilities which fall directly upon the Deputy Commander for Maintenance in an aircraft unit.
- ___ a. Schedule pilots for aircraft flights.
 - ___ b. Control maintenance spending.
 - ___ c. Fly aircraft.
 - ___ d. Assign personnel to CBPO.
 - ___ e. Provide maintenance policy guidance.
 - ___ f. Conserve utilities.
 - ___ g. Coordinate with operations.
 - ___ h. Support maintenance requirements for tenant organizations.
 - ___ i. Maintain real property in base housing.

066. Analyze maintenance control by identifying the duties and responsibilities in selected elements in its organization.

Maintenance Control. Maintenance control is the staff function responsible for directing the maintenance production activity, authorizing the expenditure of resources, and controlling the actions required to support the mission. Maintenance control manages the full cycle of production by planning, scheduling, directing, and controlling all maintenance on primary mission, mission support, and transient aerospace vehicles, including related support and training equipment. To accomplish these responsibilities, maintenance control is divided into these three functional elements: job control, plans and scheduling and documentation, and material control.

Job control. Job control is the function of maintenance control that directs and controls the use of maintenance resources. This activity controls all maintenance and services on aerospace vehicles and related support equipment by continuously monitoring status and directing maintenance actions. Job control implements the maintenance plan and schedules the accomplishment of unscheduled maintenance requirements. When a unit operates or maintains equipment on a 24-hour basis, job control must be manned accordingly.

Plans and scheduling and documentation. Plans and scheduling is the element of maintenance control that insures initiation of AFTO Forms 349 for scheduling and controlling inspections for inclusion in the daily maintenance plan. This element is also required to maintain complete records of maintenance on aerospace vehicles assigned to the Deputy Command for Maintenance. The documentation element is responsible for manually preparing documents or input to the mechanized time compliance technical order (TCTO) reporting system. Modifications of aerospace vehicles are also monitored by the

documentation element of maintenance control.

Materiel control. Materiel control provides coordination between maintenance and supply, manages supply transactions for the maintenance complex, and manages the production of assests in the repair cycle.

The efforts of materiel control must be directed continually toward maintenance support. The materiel control capability to support the maintenance effort depends upon accurate, timely forecasts of materiel requirements by maintenance managers. Materiel control does not fulfill a unit supply function. Supply responsibilities not related to maintenance support must not be imposed on materiel control.

Materiel control consists of two functions: maintenance supply liaison (MSL) and production control.

The primary responsibility of MSL is management of maintenance supply actions, which essentially consists of providing assistance to maintenance personnel in resolving their problems with supply support. Some of its responsibilities include (1) establishing a system, in conjunction with supply, for effectively programming parts, tools, and equipment requirements for maintenance and assisting in obtaining authorizations when required; (2) operating designated tool cribs; and (3) processing requirements for time change items and time compliance technical order (TCTO) parts or kits.

Production control is responsible for two interrelated functions: shop scheduling and either a reparable processing center (RPC) or a reparable asset control center (RACC). Production control responsibilities are to (1) control all reparable assets within the maintenance complex; (2) insure that supply point items requiring buildup prior to issue are processed in a timely manner; (3) accomplish the turn-in of serviceable, condemned, and not reparable this station (NRTS) components from maintenance to supply; (4) coordinate all due-in from maintenance (DIFM) matters with the supply repair cycle support unit; (5) manage the production scheduling program to include assigning in-shop priorities, controlling in-shop work, and scheduling commodity time compliance technical orders; (6) process requests for and manage local manufacture of approved items; and (7) perform necessary followup actions to resolve parts shortages.

Exercises (066):

1. What are the duties and responsibilities of maintenance control?

2. Maintenance control includes what three functional elements?
3. What functional element of maintenance control directs and controls all maintenance and services within the maintenance activity?
4. _____ is responsible for input to the mechanized TCTO system.
5. What functional element of maintenance control is responsible for controlling mission essential supply?
6. What two functions make up materiel control?

067. Identify selected duties and responsibilities of quality control.

Quality Control. Although the quality and reliability of maintenance performed is an inherent responsibility of all maintenance personnel, the quality control staff is specifically assigned to determine the quality of maintenance accomplished throughout the maintenance organization and to perform the necessary functions to manage the organization's quality control program. Maintenance supervisors are responsible for safety of flight, safety of operation, and qualify maintenance production. The combined efforts of quality control personnel, maintenance supervisors, and technicians are necessary to assure high-quality maintenance production and equipment reliability.

The quality control inspection and evaluation program provides an objective sampling of both the quality of equipment maintenance and the qualifications of maintenance personnel. In this program, quality control personnel are not an extension of the work force and are not tasked to perform production inspections as a portion of the quality control program. Production supervisors perform production inspections, such as in-process inspections, while technicians are performing maintenance on equipment in the maintenance shops. Quality control serves as the primary technical advisory agency in the maintenance activity, assisting the production supervisors and the Deputy Commander for Maintenance in the resolution of quality problems.

The evaluation and analysis of deficiencies and problem areas are key functions of quality control, since this activity must be more than inspection-oriented if it is to identify underlying causes of poor quality in the maintenance production effort. By determining probable causes of problems and recommending corrective actions to supervisors, quality control can significantly affect the quality of maintenance performed in the maintenance complex. Quality control duties include (1) performing inspections of maintenance actions, procedures, equipment, and facilities; (2) performing personnel evaluations; (3) monitoring the currency and applicability of technical data; (4) providing assistance, advice, and authoritative reference to all maintenance supervisors; and (5) maintaining the central technical order library.

In order to sustain the required performance level of the quality control function, the selection of qualified personnel is extremely important. Quality control authorizations should be carefully analyzed in order to insure that an adequate balance of specialties provide surveillance of critical maintenance functions. The deputy commander for maintenance must make sure that these positions are filled with the best qualified personnel. The individuals selected must be technically qualified, must be temperamentally suited, and must possess the communicative skills necessary for duty as inspectors. Consideration should also be given to retainability. The quality control supervisor must be completely familiar with the assigned weapon systems and supporting equipment. These minimum personnel qualifications are necessary in order to insure that quality control concepts are applied effectively and that the maintenance complex receives full benefit from the quality control function.

Exercises (067):

1. List the principal duties of quality control.
2. State the overall responsibility of quality control.
3. What does the quality control inspection and evaluation program provide?
4. Quality control personnel must be _____, and possess the _____ necessary for duty as inspectors.

068. Clarify the roles of production analysis and management administration by detailing chosen duties and responsibilities of these maintenance elements.

In proper sequence, we discuss here production analysis and management administration.

Production Analysis. Production analysis is the primary management information source for the Deputy Commander for Maintenance. It serves as a data surveillance and statistical unit. Its overall objective is to provide information to be used to improve the maintenance operation.

Responsibilities of production analysis include collection and upkeep of data pertinent to the maintenance operation as well as review of the data to identify significant trends, to isolate particular discrepancies, and to identify areas that need further study or investigation. When further investigation beyond the technical ability of production analysis is warranted, the problem is referred to the appropriate staff activities or production supervisors.

Product analysis is the key agency in the analysis of summary reports generated by the various mechanized management systems. In general, its work involves comparing performance with maintenance plans and schedules. Use of its analyses enables maintenance managers to project existing capabilities into plans and schedules and to institute controls to prevent variations. Analysis has a direct relationship with each of the staff and production activities within the maintenance complex.

Management Administration. Management administration is the management center of the maintenance complex and the focal point for all correspondence and reporting. Administration maintains files, prepares and submits maintenance reports and controls maintenance administrative procedures as directed by the Deputy Commander for Maintenance. A central administration activity permits the standardization of filing and administrative procedures within the maintenance complex. Classified documents and reports pertaining to equipment such as nuclear weapons will be maintained and prepared by the activity to which the equipment is assigned.

Administration prepares or monitors the preparation of all official correspondence and reports for which the Deputy Commander for Maintenance or his staff is responsible. The preparation and distribution of publications pertinent to the maintenance function are also responsibilities of this activity.

Administration is also responsible for sorting and grouping all AFTO Forms 349, Maintenance Data Collection Record, submitted from the productive activities prior to submission for keypunch.

Exercises (068):

1. Give the principal duties and responsibilities of the administration section within the Deputy Commander for Maintenance's complex.
2. State the objective of production analysis.
3. How do maintenance managers use the reports supplied by production analysis?
4. What step is taken by production analysis personnel when unable to complete an investigation because it is beyond their technical ability?

069. Clarify training management by citing its duties and responsibilities and describing briefly three types of training.

Training Management. The purpose of training management is to insure that a continuous, well-organized training program is established and managed throughout the maintenance complex. The maintenance training program consists of three elements: qualification training, management training, and upgrade training. This training program provides the essential element of technical and managerial proficiency to support the maintenance mission.

Training management coordinates training requirements and schedules to provide the most effective and economic use of training resources. To the Deputy Commander for Maintenance and unit training supervisors, it reports the status of training and identifies training deficiencies. In this context, "training" is defined as any instruction provided to increase maintenance technical qualifications and supervisory or management capability. It includes both informal training conducted by supervisors and technicians from within the maintenance complex and formal training conducted by such activities as field training detachments (FTDs) and mobile training teams (MTTs), factory schools, and Air Training Command technical schools.

Qualification training. Qualification training is conducted as a result of supervisory evaluations of each individual specialist's ability to perform his assigned job. This continuous process starts with the initial assignment qualification evaluation. This evaluation is based on the Specialty Training Standard (STS) or Job Proficiency Guide (JPG)

using the procedures in AFM 50-23, *On-the-job training*. After the supervisor's initial qualification evaluation is completed, reevaluation of personnel is required only when an individual qualification deficiency is identified or when a change in assignment or equipment occurs.

From time to time, special qualification certification may require evaluation and testing on an annual or other recurring basis to meet the requirements of technical orders or other directives. These special qualification requirements—such as installed engine operation, aircraft taxi, and egress training—consist of recurring training and practical supervisory evaluations with written testing, if required, to be administered by unit training or training management.

Management training. Management training is an integral part of the overall training program that is oriented to provide an understanding of maintenance management functions, relationships, and procedures. This training addresses the nontechnical proficiency needs of both supervisors and specialists in the maintenance complex. All designated maintenance personnel, excluding 3-level airmen, must be trained in the maintenance management system. The role of training management in this area is principally to identify requirements, schedule training and evaluate training results, and consolidate management training requirements for the entire maintenance complex.

Upgrade training. Upgrade training (UGT) is the program that provides the basic Air Force Specialty training to meet job knowledge and skill-level requirements. The dual-channel concept divides an individual's career development into two distinct parts: (1) the trainee acquires job knowledge through self-study of Career Development Courses and (2) he acquires job proficiency by performing under the supervision of a skilled technician. Supervisors and personnel conducting training must recognize and fulfill their responsibilities, as outlined in AFM 50-23. The directive places primary responsibility for formal UGT with the commander. Training management will not conduct, administer, schedule, or maintain individual documents for the UGT program. However, it does control and schedule initial evaluations to identify each individual's qualifications.

Training and certification for operation on powered AGE, vehicular AGE, and special equipment is required by the Deputy Commander of Maintenance.

Exercises (069):

1. What is the basic responsibility of training management?

2. In regard to qualification training, when are reevaluations required?
3. Management training provides an understanding of maintenance management _____, _____, and _____.
4. What responsibility toward UGT does training management have?
5. Describe upgrade training briefly.
6. What is qualification training?

070. State selected duties and responsibilities of programs and mobility.

Programs and Mobility. Programs and mobility provides the Deputy Commander for Maintenance with support in developing and maintaining currency of programs and plans. Also, this activity performs the function of finance, manning, and facilities management for the Deputy Commander for Maintenance.

Mobility planning. In today's Air Force entire organizations must be in a constant state of readiness for movement. Programs and mobility is responsible for developing internal procedures to insure that each maintenance activity is informed of mobility or contingency exercise requirements. In coordination with the unit mobility supervisor, programs and mobility will insure that the maintenance activities accomplish the necessary preparatory actions to meet their mobility requirements.

Financial management. Programs and mobility will assist the deputy commander for maintenance in managing maintenance financial resources. It distributes the maintenance operating budget within the maintenance complex by allocating each cost center its proportionate share of the operating budget. Programs and mobility must evaluate past expenses and current programs to determine the financial needs of the individual production activities. Factors which must be considered are these: requirements for materiel, services, travel, and civilian overtime.

Maintenance manning management. This section of programs and mobility will monitor the

maintenance manning authorizations and personnel assignments to these authorizations for the deputy commander for maintenance. They will take those actions necessary to adjust allowance documents, to plan future personnel actions, and to investigate areas where changes to either authorizations or assignments are needed. In short, the basic responsibility of this function is to maintain the available maintenance manning program.

Facility management. Programs and mobility serves as the focal point within the maintenance complex for the management of facilities. Facilities management consists of the identification of facility requirements, preparation and submission of requirements for new or additional facilities, and effective use of assigned facilities.

Exercises (070):

1. List four of the duties of programs and mobility.
2. Which section of programs and mobility distributes the maintenance operating budget to the various cost centers?
3. Describe the function of the maintenance manning section briefly.

071. Select specific duties and responsibilities of the maintenance squadrons within the maintenance complex.

Maintenance Squadrons. Let's take a look at the units of the maintenance complex that do the actual maintenance: the maintenance squadrons. These squadrons are as follows:

- Organizational Maintenance Squadron (OMS).
- Field Maintenance Squadron (FMS).
- Munitions Maintenance Squadron (MMS).
- Avionics Maintenance Squadron (AMS).

A knowledge of what each squadron is responsible for will give you a better idea of the overall function of the maintenance complex and will help you understand why some things must be done in certain ways. As we discuss each squadron, refer to figure 6-2 to see how each fits into the maintenance structure.

Organizational Maintenance Squadron (OMS). OMS has physical charge of the assigned aircraft. Each aircraft is, in turn, assigned to an individual called a "crew chief." He is in charge of the aircraft

and aircraft forms as well as any maintenance personnel assigned to work on his aircraft. Actually, we could say that the whole maintenance complex is organized to support the OMS.

Avionics Maintenance Squadron (AMS). AMS performs maintenance on avionics systems, which include such equipment as communications and navigation radios, radar, electronic radar jamming devices, and other electronic systems.

Munitions Maintenance Squadron (MMS). MMS provides reliable and safe munitions for both conventional and nuclear weapons. This includes inspection and maintenance on weapons release systems. If guns are required on assigned aircraft, MMS will provide a gun services section to maintain and inspect gun system components.

Field Maintenance Squadron (FMS). FMS provides specialist assistance to the other maintenance squadrons. It accomplishes intermediate level maintenance within the capability of assigned specialties, equipment, and facilities. The standard FMS normally includes four branches:

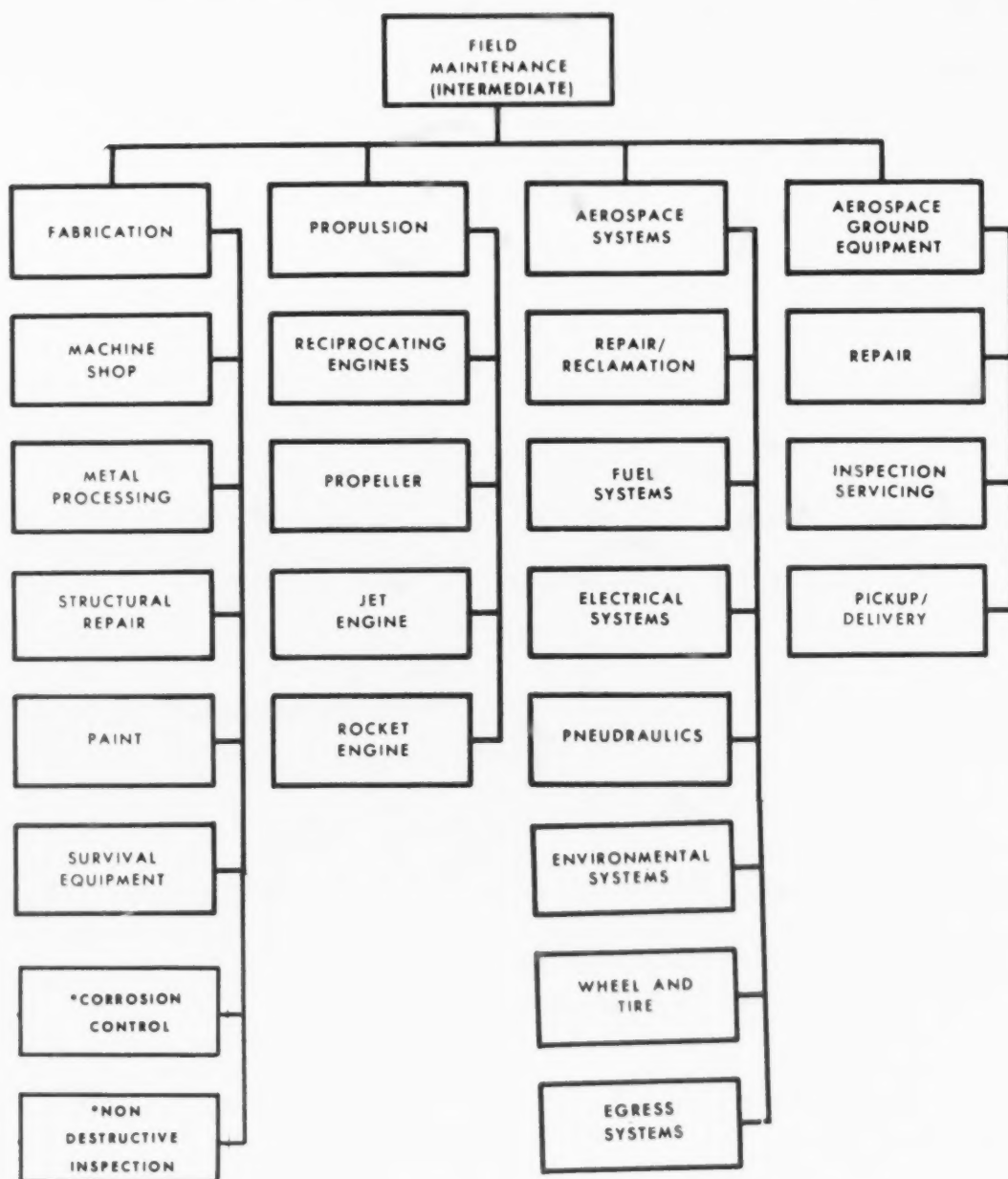
- Fabrication (FAB).
- Propulsion (Propul).
- Aerospace Systems (ASB).
- Aerospace Ground Equipment (AGE).

Refer to figure 6-3 and note where the pneudraulic shop fits into this maintenance organizational structure. Study the shops under each branch to get an idea of where other shops in the FMS fit into the maintenance complex.

Now that you have seen the agencies that help the DCM, you will better understand the next area, Maintenance Management Information and Control System (MMICS).

Exercises (071):

1. Place the initials of the squadron to which the statement refers in front of each of the following statements.
 - a. Maintains navigation equipment.
 - b. Has physical possession of assigned aircraft.
 - c. Supplies specialists to perform an aircraft engine change.
 - d. Provides a gun service section.
2. Place the abbreviation for the branch in front of each of the following shops to indicate the branch of the FMS of which they are parts. Use figure 6-3 to help you if necessary.
 - a. Jet engine.
 - b. Pickup and delivery.
 - c. Machine shop.
 - d. Pneudraulic shop.



42-1809

Figure 6-3. Field maintenance (intermediate).

072. Analyze the Maintenance Management Information and Control System (MMICS) by giving its purpose and briefly describing selected information stored in the MMICS computer.

MMICS. The MMICS system is a complex information system designed to utilize the capabilities of computer technology to provide various output products for management use. This system provides data on such items as equipment status, training, and workload scheduling. The system uses remote computer input/output devices located throughout the maintenance area. These remote units enable the operators to add, delete, update or extract pertinent maintenance data from the computer files within a matter of minutes. This eliminates long delays waiting for reports, which previously had to be researched in order to find the necessary data.

Information stored in MMICS computer. A computer can store vast amounts of information. We are primarily interested in maintenance information; so we'll cover some of the maintenance information stored and how it can be used. Some of the information that can be stored in the computer is listed below:

a. Status/Inventory. Job control personnel are aided directly and indirectly by the computer in the performance of their duties. Besides assisting in gathering maintenance information required to make decisions, the computer monitors such scheduled actions as job starts, job stops, estimated time in commission (ETIC), and acts to alert job control of possible deviations in the established schedule.

b. Operational Events. This data allows the Deputy Commander for Maintenance (DCM) and his staff to plan, execute, and evaluate the effectiveness of the unit's mission, including reasons for aborts.

c. Inspection and Time Change. This data provides the documentation section with the ability to update inspection and/or time change records, forecast TCTO and time change requirements, provides current operating time on an item of equipment, and produces a graphic display of the time remaining until inspection and/or time change.

d. Delayed Discrepancy File. This is a file of delayed or deferred on-equipment maintenance actions. The file will contain both maintenance and supply data.

e. Maintenance Personnel. This data provides the programs and mobility section the capability to maintain data pertinent to personnel assigned to the maintenance complex. Personnel listings used by the shop supervisor indicate personnel assigned to a work center by employee number. This number is used to identify assigned personnel, whether they perform direct or productive indirect labor. When personnel data changes—such as rank and labor

code—the supervisor sends a corrected personnel listing to the management support section that updates this data into the computer. When the next personnel listing comes out, this data should reflect all the changes.

f. Training Management. As the name implies, this element utilizes the computer to extend the capability of training personnel by absorbing the administrative burden of maintaining and updating files. It also provides them a pool of data from which training needs can be determined and validated. This program includes a table of courses, specific qualifications required, OJT training due dates, as well as an individual's training status and complete training history. As an example, let's say training management is going to schedule a group of individuals for training. They schedule the location, time, and make up a class roster which they input into the computer. Once this is done, MIMICS will:

- (1) Eliminate scheduling the same room, instructor, or student for two classes at the same time.
- (2) Easily update changes when they occur.
- (3) Issue a list of those attending when class starts.
- (4) Automatically update personnel records of those who completed the course.

Generally speaking, MMICS provides summarized or detailed reports concerning the maintenance activity which the DCM, his staff, branch and work center supervisors should find useful in accomplishing their portion of the overall mission.

Exercises (072):

1. What is the reason for MMICS?
2. Briefly describe how the documentation section of maintenance control can use data stored in the computer.
3. How does MMICS aid the training management section?
4. Which management section would get the most use out of data that indicates the status of equipment?

6-2. Supervision

"Why should I study supervision? I'm not the boss." This is often the attitude taken by an apprentice specialist, and as of now, it may be true in your case. But let's look at the facts. The odds are, that at some time during your first hitch, you will assume the responsibility of being a supervisor. Your first job as a supervisor may be training an airman just arriving from technical school. Your next job may be as a shift supervisor, or even supervisor, or even supervisor of the whole shop. Therefore, the following paragraphs are structured with you assuming the role of supervisor.

You may ask, "What is a Supervisor?" A supervisor is an individual who directs the efforts of one or more people in getting a job done. He is a leader and a manager. He assigns the man, lays out the details of the job, assures that the man receives necessary training, and sees that equipment and materials are assembled to perform the job. The quality of his supervision is measured by the degree of success of his unit. With this in mind, let's look at some principles of supervision that will be of benefit to you.

073. Indicate the principal responsibilities of the aerospace systems branch and the work done by typical sections of a pneudraulic shop.

The aerospace systems branch and the pneudraulic shop are our topics here.

Aerospace Systems Branch. As you can see from figure 6-3, the pneudraulic shop is part of this branch. The mission of the aerospace systems branch is to provide specialist support to other maintenance activities. The shops in the aerospace systems branch all work in direct support of the aircraft maintenance mission. A great deal of your time must be spent working with personnel from the other shops of the branch.

Pneudraulic shop. In most pneudraulic shops, we are confronted with many repair and maintenance problems. How well your shop can cope with these problems depends upon how well the assigned personnel are trained and how organized and equipped the shop is. In most maintenance organizations, the field maintenance activity supplies personnel to perform inspections, specialists for dispatch to the flightline, and personnel for the in-shop workload. Figure 6-4 shows an organizational chart for a typical pneudraulic shop.

Flight-line section. Under the setup shown in figure 6-4, the flight-line section of the shop is responsible for all specialist dispatches. When a job requiring a pneudraulic mechanic on the flight line is called into the shop, this section takes care of it. Most of the flight-line work is troubleshooting the various pneudraulic systems and removing and

replacing the system components when they malfunction. Of course, there are times when flight-line personnel will be required to help with the other fuctions of the shop.

Inspection section. The inspection section of the shop is responsible for all inspections. In most organizations, the inspections workload is quite heavy. Keep in mind that the scheduled inspection gives us a chance to look the aircraft over quite thoroughly. How well you perform these inspections determines how much unscheduled work may be required between inspections. In turn, a thorough inspection means that the aircraft can complete its flying mission as required with a minimum of downtime for maintenance. Personnel assigned to the inspection section of the shop are also required to help out in other sections of the shop as required.

In-shop repair section. The in-shop repair section has many responsibilities including the repair, overhaul, and testing of pneudraulic system components. These require that personnel working in the shop determine the amount of repair necessary to return a unit to a serviceable condition. If you are working in the in-shop repair section, you will be required to make extensive use of various kinds of test equipment which will be discussed throughout this course. Here again the in-shop repair personnel are required to help out the other sections as required.

Exercises (073):

1. What is the mission of the aerospace systems branch?
2. List the shops in the aerospace systems branch.
3. Which one of the three sections of the pneudraulic shop would perform scheduled maintenance?
4. Describe the tasks performed by the in-shop repair section of the pneudraulic shop.

074. Clarify organizational and functional charts by stating the purpose of each and briefly describing how each can be used by the shop supervisor.

Covered here are organizational charts and functional charts—in that order.

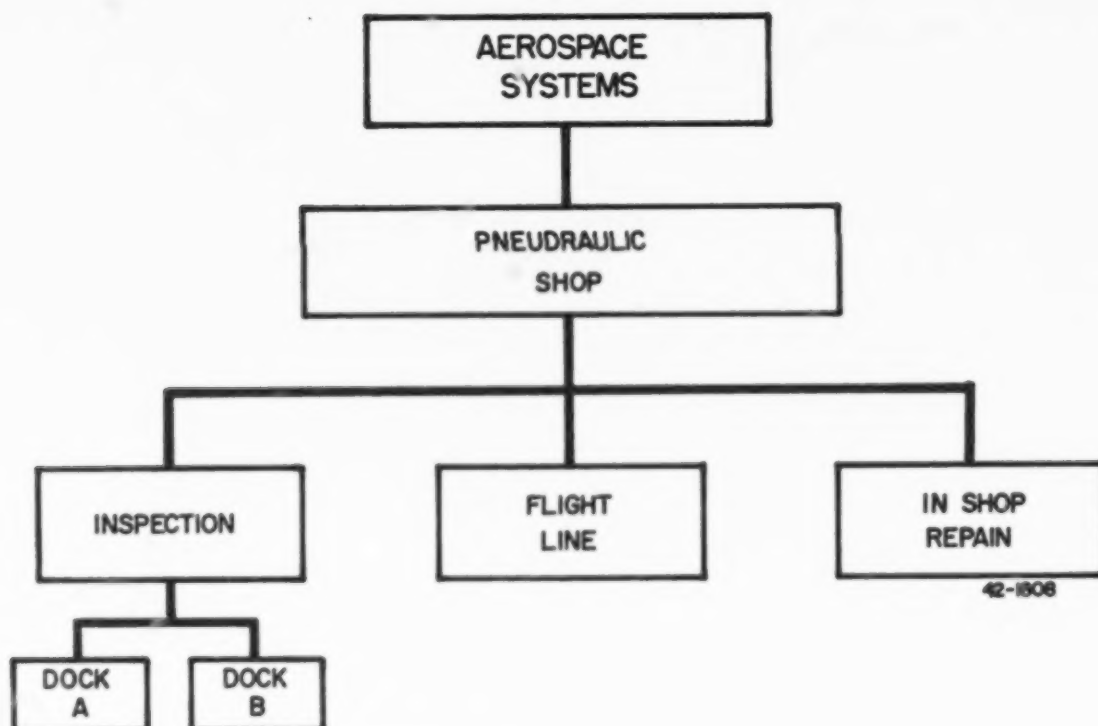


Figure 6-4. Organizational chart.

Organizational Charts. By developing an organizational chart the shop supervisor can show how his shop fits into the maintenance organization. An organizational chart normally shows one level of supervision above, and two levels below the charted position. For example, the organizational chart provided in figure 6-4 shows the pneudraulic shop as the main subject. One block above shows the aerospace systems branch, which is directly over the penudraulic shop. Below the pneudraulic shop would come the various sections that make up the pneudraulic shop, and below them perhaps would be the various subsections. Notice that the A and B docks appear under the periodics dock. Among its other uses, this hypothetical example could be helpful in orientating new personnel.

Functional Charts. A functional chart is much like the organizational chart, except that the duties and responsibilities of each position are listed on the chart. The chart may also list the job description and the AF publications required to accomplish the assigned tasks. The functional chart serves as a quick reference of what responsibilities a specific position carries with it.

Exercises (074):

1. State the purpose of an organizational chart.
2. Describe briefly one way a shop supervisor can use an organizational chart.
3. Indicate the information that is often listed on the functional chart.
4. State the purpose of a functional chart.

075. Clarify the need for coordinating work with other shops by identifying the agency responsible for maintenance organization coordination and, given a typical situation, citing the coordination required.

Work Coordination. Today's Air Force is made up of people with many AFSCs, each of them trained to accomplish work in a certain area. To name a few; there are specialists in aircraft electrical systems, instrument systems, fuel systems, and many others—including your own.

During an inspection, many of these specialists will be required to perform work on the aircraft. If all of these people were to attempt to complete their required work at the same time, you can well imagine the confusion that would be created. To avoid this and still accomplish the work in a timely manner, coordination with the other working shops is required. The coordination is usually accomplished by personnel in job control. They are the people who schedule people, equipment, aircraft, and jobs.

There may be occasions when you require an assist from an aircraft electrician in order to accomplish your specific task. First, you will explain the situation to your supervisor. He, in turn, will check the job, and through job control, arrange to have the needed specialist dispatched from the electrical shop.

Your supervisor spends many hours each week in one or another phase of coordinating. Training schedules, work programs, assigning workers to jobs and shifts—all require coordination in order to result in a well-balanced smoothly operating organization.

Exercises (075):

1. Identify the one central agency that is primarily responsible for coordination in maintenance organizations.
2. To complete a one-time inspection of the brakes on an F-4 aircraft, the tire will have to be removed first. The tire is normally removed and replaced by the crew chief. What coordination should you as the pneudraulic shop chief consider?
3. Why must the supervisor spend much of his time coordinating actions?

076. Clarify work scheduling by explaining briefly the need for planning workloads, scheduling assignments, and setting priorities and, given a typical TCTD situation, by evaluating the action taken.

Work Scheduling. The supervisor of the pneudraulic shop must run a shop that supports

fully the mission of the base. The way the shop operates to accomplish the mission is the result of his decision. His decisions, in turn, are affected by the size and shape of the shop facility, the workload, the capabilities of his people, the type of equipment maintained, and the type of supply support—or, to sum it up, his entire repair capability.

As task requirements arise, the supervisor must plan and schedule work assignments and set priorities. When planning to meet his objectives, he must check his resources, i.e., manpower and equipment. In considering his manpower requirements, he must see that he has a sufficient number of workers to perform the tasks, as well as qualified personnel. That is, he doesn't use 3-skill-level personnel for a difficult task, nor does he use 7-skill-level personnel for simple tasks. Instead, supervisors must chose the right man for the job. Equipment also is very important. Why? Because a worker cannot complete a task adequately without the proper tools. Past workloads help the supervisor in planning for the best utilization of manpower and equipment.

When planning an operation, the supervisor must consider also scheduling. He may, for example, have to schedule the use of test equipment with another section. In addition, he has to schedule his personnel for lunch breaks and other activities, taking into account work priorities and other personnel working in the same area. Finally, he must make plans that do not interfere with the work being done by other sections.

Priorities must also be considered when a supervisor is planning and scheduling. After all, the supervisor's primary concern is to keep equipment serviceable. So when setting priorities, he must schedule assigned personnel according to daily commitments. Accordingly, aircraft scheduled for flight would have the highest priority; whereas a scheduled inspection or unscheduled maintenance would be of a lower priority.

With the proper planning, scheduling, and setting of priorities, the supervisor will get the most out of his available resources. Of course, he may need refinements here and there, but such changes can be made either now or later.

Let us now examine a sample situation. Sgt Stone has volunteered to supervise a new project, involving a time compliance technical order (TCTO). He needs three people for the project. He wants about 6 hours to train the people on the first unit; after that, the time required should decrease to about 4 hours per unit.

First, Sgt Stone and his supervisor must discuss the requirements of the project and the work priorities ahead. The supervisor must check with maintenance control for scheduling. In this case, the supervisor learns that they can schedule one unit every day for a month, then two units for the

next 3 months if the program lasts that long. Barring any emergencies, Sgt Stone plans to complete the project well before that time.

Sgt Stone and the supervisor also discuss the skill levels that will be required on the project. Then they assign the specific persons that will work on the project. Sgt Stone would like to have a few additional people to train so that he will have a replacement if an emergency comes up. The supervisor, who understands the workload, agrees with the arrangement. He gives Sgt Stone the authority to accomplish his job, he assigns the people with the needed skills, and he briefs the specialist about the project.

Sgt Stone and the supervisor plan to start the project on the following Monday morning. Prior to that time, Sgt Stone will check with the electrical systems shop and get a tester. He will ask that the first unit be scheduled for 0730 hours on Monday. Now, all that the supervisor is required to do is monitor the program as time goes by to make sure that Sgt Stone is staying on schedule.

Exercises (076):

1. What must the supervisor do when task requirements arise?
2. What two resources must be considered when a supervisor plans an operation?
3. Why is scheduling so important?
4. Priorities are set for what purpose?
5. Using the TCTO situation discussed in the text, tell whether you think Sgt Stone was selfish in asking for additional personnel to accomplish the job. Explain briefly.

077. Examine personnel assignment by identifying specific aspects a supervisor considers when assigning personnel to maintenance and repair work and, given a typical assignment situation and personnel factors, assign appropriate personnel.

Assigning Personnel. You know by now that not all of our tasks are the same, nor is everyone equally trained in all of the areas of his responsibility. Therefore, as we receive units to be

worked on, we must think very clearly about which worker we want to do the work. We want to assign a specialist who can accomplish the task without too much trouble. We can use several methods to select this worker. Many people believe that a 7-skill-level technician has all of the knowledge in the world. This is not true. He may have the knowledge of the general systems and how they should work, but if he happened to come to an F-4 shop from a C-130 shop, he could be less knowledgeable than a 3-level airman. We should also realize that a 3-skill-level airman should not be sent on a job alone, especially if he is not familiar with the task.

Job knowledge, and skill level are just two of the aspects that a supervisor must consider while making job assignments. Another thing he should consider is the priority involved. In maintenance, we have schedules to meet, and we have a priority system that we work with in our duties. Very often these factors of job knowledge, skill level, and priority cause a shift of people from one job to another. Although the supervisor should try to prevent such changes as much as possible, emergencies often occur when they cannot be avoided. Normally, these emergencies occur about the time that several aircraft are scheduled to fly. When this happens, the supervisor must select the lowest priority job and place it in a "hold for personnel" status, unless, of course, he can handle the emergency with the people he has available at the time.

Exercises (077):

1. Explain the reason why a supervisor must compare the specialist's background with the task to be done rather than to his skill level.
2. As a shop dispatcher, you receive two work orders at the same time. The first task is to remove some of your equipment for bench check. The second task is to troubleshoot a difficult system. Both are priority 1 work orders. You find that you have a trained 5 skill level, a 3 skill level, and a 7 skill level. Both the 3 and 7 skill level are untrained. Assign these three people to these two jobs without pulling other people from their jobs.
3. Besides job knowledge and skill level, what other important factor must a supervisor consider when assigning people to carry out a work order?

078. State the purpose of supervisor inspections of completed work or work in progress and, given typical situations of such inspections, indicate the supervisor error or actions needed to correct poor performance.

Review of Work Quality. How many times have serious aircraft accidents been caused by the improper inspection of an item by a supervisor? To answer, look at the following situation: A supervisor is called out to perform an inspection of a component just installed on an aircraft. He knows that it is almost quitting time, and he has many things to do yet before he can be relieved. As he arrives at the aircraft, he finds out that one of his best men was involved in the installation of the part. He took it for granted that because his best man had done the job that it was done correctly. Rather than inspecting the installation, he signed the forms off. Does this sound familiar? However, by not inspecting the job, the supervisor lost the meaning of using two individuals properly—the worker who did the job and the inspector who checked the work. Yet, four eyes are almost always better than two. How? Because everyone can and does make mistakes, even the best workers you have. Conversely, if you have two people examining the work, you are more likely to insure that the job was done correctly. As the person doing the job, you should not feel downgraded by the inspector checking your work, nor should the inspector feel that it is unnecessary. Note, though, that when the supervisor inspects a completed task, he must give it a thorough examination—not just a “quick once-over.” At least two reasons exist for performing a thorough check. First, the equipment that has been worked on must operate properly for the mission's success and must be in safe operating condition. Second, inspection of completed work may be turned into an excellent learning device for the man who is in training. The supervisor's method or technique of reviewing completed work determines the inspection's usefulness as a teaching device. Where is a better place for the trainee to learn than on the equipment?

Reviewing a completed assignment requires a considerable amount of skill and tact, as well as a thorough understanding of the mechanics of the job. As a supervisor talks to the worker, he should stress both the strong and the weak points of the work. He should praise work that has been performed skillfully, even though he cannot tolerate sloppy work. As the supervisor, he should avoid criticism, sarcasm, or personal references since these comments may cut deeper than he realizes, and leave the worker with a strong feeling of dislike for him. In brief, don't just use words. Demonstrate correct procedures, and give the man the opportunity to correct his faults.

There is one other type of inspection that a

supervisor should perform. He must check job progression; he cannot wait until the job is finished. A job sometimes has to be redone if an error enters the picture before the job is completed. Failure to check job progression may also cause loss of time and work output. Furthermore, it can lead to harsh feelings and the loss of ambition on the part of the man who finds his efforts wasted because he was forced to do the same job over.

Exercises (078):

1. As the supervisor arrives, the last item has been installed and the unit is being readied for an operational check. He watches the operational check being accomplished and the system worked. He directs the workers to panel the unit up. Explain what error the supervisor committed.
2. Explain briefly why the supervisor should review the work that has been accomplished by his workers.
3. The supervisor finds on an inspection that a task has been done in an outstanding manner except that the holddown mount bolts are safety-wired backwards. Clarify the actions that he should use to correct this task in order to prevent its happening again.
4. Tell why it is better to check the job several times while the work is being accomplished rather than waiting until the task has been completed.

079. Examine maintenance/inspection reports and charts by giving their purpose and specific uses and, in a given situation, the records most helpful to a supervisor.

This LO will cover maintenance records and charts and graphs—in the order named.

Maintenance Records. Maintenance and inspection reports are very important in the work life of a supervisor. He has many daily and monthly maintenance reports which he can use to give him an idea as to where the workers are being employed most of the time. These reports are prepared from information that is supplied on maintenance forms. For example, maintenance data collection records (AFTO Form 349s) are kept on

file in the shop. Similarly, historical records for each aircraft are on file at the documentation section.

If an individual is assigned a job on an aircraft and time permits, he should first check that aircraft's history before rushing out to it. Why? Because his review of these files may help him pinpoint a possible trouble cause before he actually goes to work of that aircraft. This review is often overlooked by new workers. Yet, the few minutes required to check the file may save them hours in the long run.

Charts and Graphs. Charts and graphs are also often useful to the supervisor; using them he can compare several items against one another, such as "time" versus "failures." Be cautious, however, regarding the "built-in" limitation of charts and graphs; i.e., they must not be so complicated that they cannot be read. Actually any chart, such as a training chart, can indicate many training operations and still be readable. However, if the supervisor starts adding leave schedules, annual shots, and many other details about his people to a chart, it cannot be used to determine quickly training operations. Graphs are even more limited in this regard than are charts. In fact, as a "rule of thumb," to be readable and comprehensible, a graph should be limited to five items or fewer.

Exercises (079):

1. Why would the supervisor be interested in the time taken to accomplish a task as shown on maintenance reports?
2. Some mechanics from your shop have worked all night on a troubleshooting problem without locating the trouble. Your supervisor, after consulting some maintenance records, quickly solves the problem. Which records would the supervisor likely have found helpful?
3. How many separate graphs should be used normally to show 11 items?

080. Given several hypothetical situations, cite the purpose and procedures for establishing work methods, controls, and performance standards in each.

Our topics in this LO are performance standards, control standards, and performance reports—in that sequence.

Performance Standards. A supervisor must see that the people in his shop accomplish their tasks. Accordingly, to insure that his personnel do meet their objectives, he must set standards for them. These standards should be set at a level that can—in all fairness—be expected of any qualified, competent worker. After all, it is generally true that workers become frustrated and quit trying to reach a goal if it has been set too high. Thus, the requirement must be set at a level attainable by the average worker. The supervisor then uses these standards to judge established work methods and to spot faulty areas. For example, he uses a checklist and/or a technical order for each task. For the most simple task, he checks to see that his workers have the needed technical data. He also checks for proper care and handling of test equipment, cleanliness in shop areas, safety procedures, and proper dress and grooming of personnel. During his daily activities, he should look around his area and make sure that his people are meeting the standards.

Control Standards. In the event that an area is falling below standard, the supervisor should set up a program to bring it up to standard. Why? Because if he lets the condition "slip by" for awhile because he has other things to worry about, the substandard condition may come to appear to be the standard. The supervisors below him should help him to determine when an area is becoming substandard. These supervisors should be assigned the specific responsibility of helping to maintain the standards. In other words, they must do their share of evaluating work.

Performance Reports. The supervisor judges people every day as he comes into contact with them. Some are outstanding persons, others are just ordinary everyday-type people, and still others are undesirables. He should keep these judgments in mind. Eventually, he may have to write an airman performance report (APR) on these people. Every enlisted person in the Air Force receives an APR at least once a year. There are a few other times when APRs are submitted. Examples are when there is a change of reporting official (CRO) or when a man is being removed from the control roster.

These performance reports are used to select the best airman/noncommissioned officers for promotion. Certainly, not everyone assigned to a section can be promoted as soon as he has acquired time in grade. Noncommissioned officer and airman performance ratings are recorded on one of the following AF Forms:

- AF Form 909, Airman Performance Report.
- AF Form 910, TSgt, SSgt, and Sgt Performance Report.
- AF Form 911, CMSgt, SMSgt, and MSgt Performance Report.

TSGT, SSgt AND SGT PERFORMANCE REPORT																						
I. IDENTIFICATION DATA																						
1. LAST NAME - FIRST NAME - MI Asselin, Roy R.	2. SSAN 021-30-6330	3. GRADE SSgt																				
4. ORGANIZATION, LOCATION, AND COMMAND 99 Orgl Maint Sqdn Clark AFB, Philippines (PACAF)	5. RESERVE WARRANT OR COMMISSION GRADE AND SSAN None	6. REASON FOR REPORT ☐ NO REPORT 1 YEAR ☒ CHANGE OF REPORTING OFFICIAL ☐ NO REPORT 6 MONTHS ☐ DIRECTED BY _____																				
	7. PERIOD OF REPORT & SUPERVISION FROM 1 Dec 72 THRU 24 Apr 73 NR DAYS 144																					
11. DUTIES: PAFSC 43151E DAFSC 43171E CAFSC 43151E CURRENT DUTY: Inspects, repairs, maintains, services, and modifies aircraft and aircraft installed equipment; performs crew chief, flight chief, and maintenance staff functions; and performs tow reel operator functions.																						
III. PERSONAL QUALITIES																						
1. PERFORMANCE OF DUTY: Consider the quantity, quality, and timeliness of his work in the duties described in Section II.	REPORTING OFFICIAL ☐	<table border="1" style="width: 100%; text-align: center;"><tr><td>N/O</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>										N/O	0	1	2	3	4	5	6	7	8	9
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2. WORKING RELATIONS: Consider how well he used his ability to communicate (oral and written) and to get along with others to improve his overall performance.	REPORTING OFFICIAL ☐	<table border="1" style="width: 100%; text-align: center;"><tr><td>N/O</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>										N/O	0	1	2	3	4	5	6	7	8	9
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3. TRAINING: Consider how well he discharges his responsibilities as an OJT supervisor, trainer, or trainee and in other efforts to improve his technical knowledge and educational level.	REPORTING OFFICIAL ☐	<table border="1" style="width: 100%; text-align: center;"><tr><td>N/O</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>										N/O	0	1	2	3	4	5	6	7	8	9
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4. SUPERVISION: Consider how well he supervises, leads, uses available resources, and maintains good order and discipline.	REPORTING OFFICIAL ☐	<table border="1" style="width: 100%; text-align: center;"><tr><td>N/O</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>										N/O	0	1	2	3	4	5	6	7	8	9
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5. ACCEPTANCE OF NCO RESPONSIBILITY: Consider his acceptance of responsibility for his actions and those of his subordinates.	REPORTING OFFICIAL ☐	<table border="1" style="width: 100%; text-align: center;"><tr><td>N/O</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>										N/O	0	1	2	3	4	5	6	7	8	9
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6. BEARING AND BEHAVIOR: Consider the degree to which his bearing and behavior on and off duty improve the image of Air Force NCOs.	REPORTING OFFICIAL ☐	BR	<table border="1" style="width: 100%; text-align: center;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																			
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IV. OVERALL EVALUATION																						
How does he compare with others of his grade and Air Force specialty? Promotion potential is an essential consideration in this rating.																						
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AF FORM 910
JAN 71

PREVIOUS EDITIONS WILL BE USED.

Figure 6-5. AF Form 910, TSgt, SSgt and Sgt Performance Report (front).

Let's briefly take a look at a performance report that would normally be written for a noncommissioned officer. Study figure 6-5 as we proceed. Notice, that under the title of "Personal Qualities" appear six areas in which the NCO is rated. These ratings range from 0 (the lowest) to 9 (the highest). Remember, a supervisor should try to rate his workers as fairly as possible. Regretably, so-called "average people" are the hardest for a supervisor to rate fairly. To do so, he must compare them with other personnel of the same rank, skill level, and job knowledge. Also, appearing at the bottom of the form is an overall evaluation section, where the worker involved is again rated from 0 to 9. Remember, the higher the numbers, the better a worker's chance for promotion. So we should do his best, because his supervisor is continuously evaluating him against the other personnel.

Exercises (080):

1. At what level should the supervisor set performance standards?
2. A supervisor notices that one of his workers needs a haircut. He corrects the situation immediately. Give the reason for his supervisor correcting this worker so soon.
3. At your last record check you noticed that your last APR was submitted in the month of July of this year. Having only been in service now a little more than 1 year, you can figure out when the next one should be submitted unless there is a CRO in the meantime. Identify the month in which your next APR should be written.
4. As a supervisor, you must fill out the AF Forms 909, which rate airmen on their abilities in certain areas. You want to rate three average airmen fairly. Clarify the method you should use as a guide.

081. Identify factors, actions, and means used to authorize and justify personnel and equipment.

First, equipment authorization; then, second, personnel and equipment justification are looked at here.

Equipment Authorization. The equipment authorized for your unit is based on two general

factors, the unit mission and the number of people. These factors are interrelated. For example, if the performance of the mission requires certain vehicles, then operator personnel must be authorized. As people are authorized, quantities of other types of equipment based on the number of people are affected.

The equipment authorized your unit is based on USAF allowance documents. These documents reflect the average minimum quantities of equipment items needed to accomplish the mission. However, the allowance documents do not necessarily reflect the exact quantities your unit will be authorized. Exact quantities are determined by major commands and base equipment management offices. They are influenced by such factors as the number of aircraft to be maintained, the size of the workload, the type of maintenance performed, the number of personnel, and the climatic conditions involved.

Tables of allowances (TAs). The USAF tables of allowances are the authorization sources quoted in requests for issue. AFR 0-10, *Index of Allowance Source Codes*, is the index of TAs. This provides a list of items of equipment in the quantity normally required by the mission of an Air Force activity. Repair parts are not listed. Some examples of TAs are:

- TA 738, Aircraft Pneudraulic System, Intermediate Maintenance (for pneudraulic shop).
- TA 333, F/RF-4 Weapon System (for an organization performing aircraft maintenance).

Personnel and Equipment Justification. Justification of personnel and equipment has been discussed briefly earlier in this chapter. You already know that to accomplish the mission, you must have the necessary equipment and manpower. In today's Air Force, aircraft systems are being modified every day. Some system may be removed, improved, or replaced with a completely new system. This may affect the manning and required maintenance equipment. Overtime required to support the mission may indicate undermanning or lack of training. There are many other areas that the supervisor must look at very closely as he justifies personnel. Look at the unit's mission for a starting point. Are the temporary duty (TDY) assignments compiled correctly? Are tasks accomplished that are normally assigned to other sections? Has the wing been assigned additional flying hours? Has transient aircraft traffic increased? The final question: Are these conditions going to be temporary or permanent? The supervisor also checks the unit detail listing (UDL) to see how many workers are authorized. The UDL may authorize more people than are presently assigned. It should be brought to the attention of

the commander whenever the mission cannot be properly supported.

Before personnel and equipment can be justified, it is important that the supervisor have all of the facts and discuss them with the commander. Normally, the commander keeps a close watch over the wing's manning and equipment authorization. It is possible, however, that the shop supervisor may supply one small fact that may be a justification for an emergency manpower request. The same is true of equipment. The replacement of faulty equipment or of that which is in limited supply and hard to repair may be justified. The commander may want to review the facts with the supervisor to insure that he has all of the necessary information. In all such cases he must have all of the facts before going to higher echelons for help.

Exercises (081):

1. List the factors used to justify personnel and equipment.
2. After considering the changing aspects of the unit's mission, the supervisor should compare the number of personnel assigned with the number of personnel authorized. Where can he find out how many workers are authorized?
3. If the supervisor needs more men or more equipment than currently authorized, what action should he take?
4. The USAF allowance documents reflect the average minimum equipment needed to accomplish the mission. Who determines what quantities are issued?
5. List factors that may be used to arrive at a specific number of authorized pieces of equipment.

082. Detail selected actions that can be taken to resolve technical problems, correct substandard personnel performance, and conduct disciplinary actions involving subordinates.

In sequence we cover here technical problem solution, the correction of substandard personnel performance, and disciplinary action.

Solving Technical Problems. When you become a supervisor you will be called upon many times to

resolve technical problems. "Ask the boss" is the standard answer when anyone encounters a problem. When you are that "boss," you must come up with the answers. The answers you give will go a long way in establishing your reputation as a supervisor.

When you attempt to provide a good answer, your past experience may be of use to you in the form of so-called "tricks of the trade." On the other hand, you may have to research TOs or manuals to come up with the answer. Perhaps just telling the worker with the problem where to go to find the answer will suffice. Another possibility is that you will have to ask for outside help because the problem is beyond your knowledge or ability to solve. Regardless of the type of situation, never leave a problem unsolved if it is possible for you to solve it. If you refer one of your people to someone else for a solution to a problem, check back with him later to see whether or not he has found his answer. By your doing this, your people will get the feeling that their problems are your problems (which they are), and your reputation as a supervisor will grow.

Correcting Substandard Personnel Performance.

As we have stated earlier, when a unit begins to fall below standards, a program should be set up quickly to correct it. The same is true for personnel performance. When a supervisor observes sloppy workmanship, poor grooming, or missed appointments or training sessions, he should take action. It is important that corrective action fitting the situation be applied.

Correcting substandard personnel must be done quickly but fairly. It can begin with a simple counseling session to inform the substandard worker what is expected from him at all times. This may be all the action that is required. In some cases, several of these counseling sessions may be required before standards are met.

Disciplinary Action. For personnel who cannot be corrected by counseling sessions, the supervisor may initiate the next step: he could discuss the situation with the commander and furnish him with the facts. The commander may then apply greater pressure on the individual in the form of reprimands. There are two types of reprimands that can be used. The first is the verbal reprimand. This is much like the counseling at section level. Normally the individual begins to understand that to carry on with this substandard performance may bring even more severe consequences. The second type of reprimand is a written reprimand. This is entered into the individual's records and will reduce his chances of promotion.

The commander has a few additional avenues open to his use. He has the Article 15, which he can use as squadron level punishment. Under the Article 15, the commander can reduce the individual in rank, fine the individual, or use both

punishments. In more serious cases, he may elect to refer the case for court martial. This may even lead to a recommendation for discharge under conditions of AFM 39-12, *Separation for Unsuitability, Unfitness or Misconduct; Resignation or Request for Discharge for the Good of the Service; and Procedures for Rehabilitation Program*. This is used rarely, of course.

Exercises (082):

1. When someone encounters a technical problem he cannot solve, where does he normally go for assistance?
2. If one of your workers comes to you with a problem that you cannot answer, what action should you take?
3. When you refer one of your people to someone outside the organization for assistance on a problem, why should you check to see that he gets a satisfactory solution?
4. What action should the supervisor take first to correct a substandard individual?
5. What should the supervisor point out to the individual during counseling?
6. What action can be used if counseling has little or no effect?
7. Give those actions that the squadron commander may take at squadron level.
8. What action is taken as a last resort for substandard performance?

083. Give specific methods, actions, and steps used to counsel personnel and resolve individual problems.

Resolving Personnel Problems. Workers with problems may need assistance from the supervisor or from some other qualified person. It is too bad that people are unable to keep their problems from affecting their work, but few can. Therefore, the more of their problems that you help resolve, the less these problems will affect their work. Workers' problems normally do not follow a particular pattern; therefore, each one must receive special attention.

There may be problems you cannot solve without the help of your supervisor. There may be others you cannot solve without the help of some staff agency, such as the personnel office. You can solve problems within the scope of your authority without outside help. Those beyond your authority must be referred through formal channels, to higher authority for action. But, by far the best procedure is to handle dissatisfaction before it gets a chance to get into formal channels. In other words, try to stop trouble in the early stages before it gets out of hand.

Since a worker's problems are also the supervisor's problem, let's talk about how to handle them. You can use the systematic problem-solving techniques. When workers show signs of being in trouble, you should talk to them to find out what is wrong. Be sure to gather available information before the talk. Talk in a private place. Be a good listener. Base the discussion on facts. Then follow up.

It is easy to see why these factors are important. Since the purpose of talking to the workers is to get their story, you should let them do most of the talking. After they tell their story, it may help you to restate their problems just to be sure you understand the situation. Define their problems with them. This is often an effective way to help people clarify their problems in their own minds. You may also ask for clarification on some points that may cause the problem to be reevaluated. The process of restating the problem will sometimes suggest a solution. At least the individual feels better when he "gets it off his chest." By listening, the supervisor has gathered valuable facts and may have put the complaining worker in a better frame of mind. The nature of the complaint will suggest whether it must be investigated further, whether you can handle it yourself, or whether it must be referred to someone else better qualified in these matters. We often find that many of the dissatisfactions of workers are relatively small problems with solutions that are easy. But, even little problems will grow into big problems if they are mishandled or ignored. A dissatisfied or disgruntled worker finds fault with many things. Also, they may stir up trouble among other workers.

This points out the necessity of trying to stop trouble in its early stages. Sometimes this is

difficult to do unless you are alert, and have studied the individual differences among your workers. Also, maintain a good relationship with each worker to be sure that he isn't afraid to discuss his problems with you. If a supervisor has earned the workers' confidence, they will come to him with their problems. This is a true test of the confidence that they place in him. There are many cases on record where a worker has trouble "off the job." He then either consciously or unconsciously transfers his troubles to the job. Sometimes the supervisor's first indication of difficulty is when the worker makes a complaint. In such cases, it is apparent that the supervisor may not have gained the confidence of the workers.

Listed below are four basic steps involving problem solving:

1. Get the facts.
2. Weigh and decide.
3. Take action.
4. Check results.

Exercises (083):

1. Why is it important to have an individual restate his personal problems?
2. Why should the individual being counseled do most of the talking?
3. If, as a supervisor, you cannot solve an individual's problem, what action should you take?
4. List the four basic steps involved in problem solving.
5. Why should the supervisor get involved with an individual's personal problems?

084. Indicate specific methods for changing policies on the utilization of personnel and equipment.

Improving Methods. The world beats a path to the door of the man who invents a better mousetrap. This is a true statement, and it will apply to much more than just mousetraps. A safer, cheaper or faster method will always be in demand, whether or not you are in the Air Force. If you know a better way of doing something, you should try to get that way adopted. The Air Force is

always looking for improved methods. One way to initiate a change is through the chain of command.

Chain of command. You may feel you have an idea that can improve shop practices and want to adopt it. The chain of command method begins with your supervisor. You discuss your idea with him. It may end there, or you and he may go to see his supervisor. You may talk to everyone, all the way up to the commander, and either your idea will be used or you will know why it can't be used.

Complaint program. Another way to change things is through the complaint program. Every squadron has a complaints NCO and a complaints officer. If you don't like the way something is done, this program gives you an opportunity to do something about it. You discuss the problem with the complaints NCO or officer and obtain his help in correcting the situation.

Suggestion program. Figure 6-6 illustrates a suggested improvement. This improvement is for the safety of pedestrians and is submitted on AF Form 1000, as all suggestions should be. A suggestion does not have to be work related, as we have illustrated.

The Air Force will pay a suggestor part of the overall savings if his suggestion to save time or material is adopted. Obviously, all suggestions will not save money, but don't let a lack of monetary value stop you from submitting a suggestion. Such safety suggestions as shown in figure 6-6 will not save money but may save a life. Worthwhile suggestions such as this one are appreciated and receive recognition.

AF Form 1000 is self-explanatory, and you can complete it very easily. Your name doesn't even have to be involved if you check the No block in section I. Fill in sections I and II as explained on the form. Section III will be returned to you when your suggestion is received at the base suggestion office.

Exercises (084):

1. List three methods of initiating a change.
2. Which method of initiating a change does the Air Force actually pay the individual responsible?
3. When you propose a change in methods, through the chain of command, and the change is disapproved, what may you expect from the disapproving authority?
4. Who is your first contact in the complaints program?



HOW TO MAKE YOUR SUGGESTION

DISCUSS: Discussion with your supervisor is encouraged.
COMPLETE: Complete all blank spaces in Sections I and II, except "Suggestion No." In Section III enter "Subject Of Suggestion" and your name and mailing address.
SIGN: Be sure to sign your suggestion in Section I.
ADD: Use additional sheets for drawings or pictures when necessary. Attach separate sheet for co-suggestor's Personal Data Information.
SUBMIT: Suggestion may be submitted through your supervisor, placed in a suggestion box, or mailed to the Suggestion Committee.

IMPORTANT! SUBMIT ALL SECTIONS OF THIS FORM—DO NOT DETACH ANY SECTION.

SUGGESTER'S PERSONAL DATA			
NAME OF SUGGESTER (Last, First, Middle Initial) (Include Serial Number, if Military)		HOME OR MAILING ADDRESS (Include ZIP Code)	SUGGESTION NO.
RICHARD, JOSEPH D. H. PRO30-38-7164		244 Lilac, Rantoul IL 61866	
MR.	MISS	(If different from above, legal address for tax purposes)	
MR.	MISS	(Same)	
GRADE	SOCIAL SECURITY NUMBER	POSITION TITLE (Add AFSC if military)	OFFICE PHONE
SSgt	030-38-7164	Technical Writer T53270	2545/3419
INSTALLATION, ORGANIZATION AND/OR SYMBOL			
3349 Instructor Sq/TWSTC/CHANUTE			
SUBJECT OF SUGGESTION			
SAFETY OF PEDESTRIANS			
I HEREBY AGREE THAT, UPON ACCEPTANCE OF A CASH AWARD(S), THE USE OF THIS SUGGESTION BY THE UNITED STATES SHALL NOT FORM THE BASIS OF A FURTHER CLAIM OF ANY NATURE UPON THE UNITED STATES BY ME, MY HEIRS, OR ASSIGNS.			
DATE	SIGNATURE OF SUGGESTER	MAY YOUR NAME BE USED DURING THE PROCESSING OF THIS SUGGESTION?	
17 Oct 74	Joseph D. Richard	☒ YES ☐ NO (If "No", do not complete first line in Section II.)	

SUGGESTION		
AWARDS COMMITTEE WILL DETACH THIS PORTION BEFORE FORWARDING FOR EVALUATION		
NAME OF SUGGESTER (Mr., Mrs., Miss, Military Grade)	ORGANIZATION AND/OR SYMBOL	OFFICE PHONE
SSgt JOSEPH D. H. RICHARD	3349 Instructor Sq TWSTC	2545/3419
I BELIEVE THIS SUGGESTION WILL		SUGGESTION NO.
☐ SAVE TIME ☐ SAVE MATERIAL ☐ IMPROVE METHODS ☒ IMPROVE SAFETY ☐ SIMPLIFY WORK		
DESCRIBE SUGGESTION COMPLETELY. TELL WHAT THE PRESENT PRACTICE IS, CHANGE THAT IS SUGGESTED, WHERE (Indicate OPR) AND HOW CAN IT BE USED, AND BENEFITS TO BE DERIVED FROM ITS USE. (If suggestion is hand-written, please use black pencil or black ink, if possible.)		
I FEEL THERE IS INSUFFICIENT LIGHTING ON ENTRANCE DRIVE BETWEEN A STREET AND M STREET FOR THE AMOUNT OF PEDESTRIAN TRAFFIC IN THIS AREA AT NIGHT. THERE ARE CURRENTLY SEVEN CROSS WALK AREAS AND ONLY FIVE STREET LIGHTS. THIS CREATES A HAZARD FOR MOTOR VEHICLE OPERATORS IN SEEING THE PEDESTRIAN WHILE DRIVING WITH LOW BEAM HEADLIGHTS. THIS IS TRUE EVEN AT 15MPH BECAUSE OF THE PEDESTRIANS DARK COLORED CLOTHES DURING THESE WINTER MONTHS. I SUGGEST ONE STREET LIGHT BE PLACED AT EACH CROSS WALK.		
(Continue on Reverse)		

SUGGESTION ACKNOWLEDGEMENT	
SUBJECT OF SUGGESTION	SUGGESTION NO.
THANK YOU FOR YOUR SUGGESTION. IT HAS BEEN ASSIGNED THE ABOVE SUGGESTION NUMBER. CAREFUL CONSIDERATION WILL BE GIVEN YOUR SUGGESTION, AND YOU WILL BE INFORMED WHEN ACTION IS TAKEN. YOUR INTEREST IN PRESENTING THIS IDEA IS APPRECIATED. (Use above number in checking status of your suggestion.)	
DATE	EXECUTIVE SECRETARY, AWARDS COMMITTEE
TO:	IMPORTANT! Please print your name and mailing address (home or office) in the space provided at left, keeping within the printed corner marks. If home address is given, include ZIP Code.

Figure 6-6. AF Form 1000 (Suggestion form).

Safety

SAFETY, SAFETY, SAFETY! You have heard it before and you will hear it again. After all, you hear safety talks at the weekly safety briefing, the shop chief preaches safety, and everytime a holiday comes along—another safety briefing. Just ask yourself, what does safety do for me. This is a fair question and deserves a fair answer. Would you accept a loss of an arm, a leg, an eye, or even your life? Or maybe just a painful broken hand or skinned knuckle! We have mentioned a few of the outcomes of accidents, but what can be done to prevent such losses? If each of us will practice safety, we can reduce the number of these so-called "accidents." We say "so-called" because most of them are actually caused by the unsafe acts of people. For example, some conditions that contribute to unsafe acts are: speeding up to get a job done, fatigue, uncertain or poor morale, and unawareness of technical and safety directives. So the only answer for us to be safe on and off the job is: Don't take chances. It may take you a little longer, but do things the right way, the safe way, and prevent pain and damage.

What's in it for the Air Force? The answer is simple—the mission. Every accident, minor or major, hurts the Air Force mission. What happens when you get hurt and go to the hospital? Well, you are still on the payroll; the doctors are on the payroll; time is lost; someone else has to do your assigned job, or it has to wait until you return. These result in much extra expense for the Air Force, unnecessary pain for you, or a job not being done! The bad part is that most of these things can be prevented. Air Force Regulation 127-101, *Accident Prevention Handbook*, is a source of information for the prevention of accidents. Its goal is to reduce and ultimately eliminate accidents—thus to reduce injury to personnel and damage to equipment.

Many hazards exist which you may encounter in your job as an aircraft pneudraulic mechanic. Some of these we shall cover in this section so that you may have an idea of the danger areas involved. These are not all of the danger areas, but these dangers are, we believe, the ones you will come in contact with more often.

7-1. Shop Safety

Sometime in your career as a pneudraulic specialist you will have to work in the shop. This could be manufacturing hoses, using test equipment, repairing parts, or loading or unloading equipment or parts. This section of this chapter is designed to acquaint you with the dangers you may run into while working in the shop. In many instances, for example, you will be using compressed air, or nitrogen, which if not used properly, could cause severe damage or injury. Solvents and combustible material will also be used; so we will cover types of fires, fire extinguishers, and methods of putting out fires.

085. Examine safety training and ground safety by citing the common causes, effects, and controls used in ground safety and the specific steps in safety training.

The principal objective of ground safety is to eliminate or at least minimize accidents. This may be done by taking the following factors into consideration:

- Accident causes.
- Effects of accidents.
- Controlling accidents.

Preventing Accidents. Accidents do not happen without cause, and the identification, isolation, and control of these causes are the underlying principles of all accident-prevention techniques. Even natural elements can be controlled to some extent. Certainly, accidents caused by such phenomena as lightning, storms, and floods are extremely difficult to prevent. Still, the effects of these can be minimized. For example, aircraft can be secured when strong winds are expected. Accidents due to nature, estimated at only about 2 percent of all accidents, are classified under the term "natural phenomena." (See fig. 7-1.)

Theoretically, preventable accidents can be traced to the background and environment of individuals.

ACCIDENT CAUSES

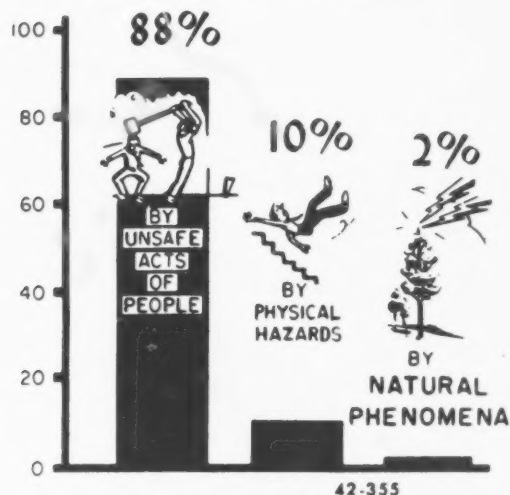


Figure 7-1. Accident causes.

These tendencies manifest themselves in personal characteristics that allow an individual to perform an unsafe act or overlook or tolerate an unsafe condition that could result in an accident. The injuries, property damage, and loss of combat capability that follow complete the costly sequence. Surely, it is extremely difficult to detect and eliminate such characteristics as inattentiveness, excitability, impatience, and stubbornness. On the other hand, a relatively simple and effective means of accident prevention is to eliminate unsafe acts and conditions.

All unsafe acts and conditions may be considered direct causes of any accident. When these direct causes are removed, the sequence is interrupted, and the accident cannot happen. Fortunately, we can usually anticipate, readily identify, and immediately eliminate these unsafe acts and conditions. With this in mind, practical accident prevention measures are designed to prevent or eliminate direct causes, and suitable controls have been developed for this purpose. Adequate safety training is the most effective way of preventing "manmade" accidents.

Safety Training. This is a specialized form of education to prepare an individual to do his work safely with minimum supervision. To begin with; in order to insure maximum safety, each airman should receive specific instructions about his job so that he is fully aware of the dangers involved and the safety practices required to offset them. Following this process, he should develop a safety consciousness, and when this has been properly ingrained, he should function without the need for mechanical safeguards or enforcement pressures.

Remember, when you teach a person the *right* way to do something, it is impossible not to teach him the *safe* way simultaneously. When this is done, you will develop safe and efficient employees. Note that this training should be both initial—i.e., when a new man enters the shop—and recurring—the latter to meet operational changes. The most frequently employed methods used to teach these things are personal interviews by the supervisor and 5-minute "standup" talks. Remember, too, that safety training must be continuous to keep it from being lost in the middle of all of the other instructions people receive.

Important steps in training are:

1. Analyze the job. Break down and analyze in detail each job for which training is given. Designate specific dangers.
2. Establish safe practices. Where it can be done, eliminate hazards and develop safe practices or protection from remaining hazards.
3. Analyze the individual. Study individuals under training with reference to their personal qualifications and characteristics. As they apply these to the job, determine whether or not additional or special training is necessary.
4. Plan the training. To maintain the worker's interest, plan his instruction. This helps impress him with the importance his supervisors place on safe habits and practices.

Exercises (085):

1. Name the classification given to accidents caused by such conditions as lightning, storms, and floods.
2. Identify the causes of accidents that are the easiest to eliminate.
3. Name personal characteristics that are difficult to detect and counteract.
4. What is considered the most effective way of preventing "manmade" accidents?
5. Explain briefly why the supervisor must analyze each individual under training.

086. Relate selected responsibilities, dangers, areas of concern, and safety precautions involving good housekeeping procedures.

The work center supervisor has primary responsibility for seeing that good housekeeping procedures are followed and unsafe conditions are eliminated. Of equal importance, however, is the worker's adherence to good housekeeping practices. So, whether you are assigned as a supervisor (a distinct future possibility) or as a worker, you must learn more about this subject and follow the procedures which help to eliminate accidents.

Indoor Housekeeping. The principal precautions which must be observed in interior housekeeping include the arrangement of work areas and lighting; tool and materials storage; and the removal of scrap, waste, and spills.

Arrangement and lighting. The indoor arrangement of facilities in which you work is of great importance. When a work area is designed, it should be laid out to simplify the practice of good housekeeping. This allows orderly operation and helps to avoid congestion in work areas. Good layout of installations can best be achieved in the planning stages, but your interest and suggestions after the fact can also help insure a safe work center.

Badly lighted areas contribute to poor housekeeping practices and accident possibilities. Insure that all workbenches, aisles, stairways, and rooms remain adequately lighted during use. If an area is not properly lighted, either correct it yourself or notify your supervisor, so that he can have the situation corrected. All fluorescent lighting fixtures should be protected with shields or clamps in such a manner as to keep the tubes from falling.

Storage and disposal. The residue of work is often in the form of waste paper, wood or metal scraps, old components, or dirty rags. Do not allow these items to accumulate in your work area. Instead, find suitable containers to store them in until they can be disposed of properly. Use separate containers for different materials, such as metal, wood, paper, or cigarette butts. NEVER put smoking materials or cigarette butts in any container unless it is designed and marked specifically for that purpose. Use plainly marked metal containers with self-closing lids to dispose of combustible wastes, rags, and other flammable materials. Do not allow scraps and waste to accumulate and unnecessarily clutter up your work area. Dispose of them daily or move them to a safe location.

Oil, water, and other such substances on floors can cause slips and falls. Clean up this type of mess immediately to keep it from causing an accident involving yourself or a co-worker. If flammable liquids are spilled, make sure that you thoroughly remove the spill by using noncombustible absorbent materials.

Do not leave tools and materials on equipment racks, desks, or workbenches, where they might be knocked off or fall. Use suitable toolboxes or racks

for safe tool storage. A good rule is: "A place for every tool and every tool in its place." Store paper, books, shoeshine kits, and all other materials in their proper place. If you must temporarily allow a potentially dangerous condition to exist, post warning signs or otherwise warn others so that they will be aware of the hazard.

Outdoor Housekeeping. Good housekeeping is as important outdoors as indoors.

Storage. Storage areas are of concern to us here also. Materials should never be stored under outside stairways. Boards stacked under an open stairway, for example, may slip from the stack, project through an open step or out to the side of the stairway, thus tripping someone. Also, this creates a potential fire hazard. If the stairs catch fire it eliminates a path for escape. Be careful not to store materials in such a way as to block doors or exits. In addition to the danger of causing a fall, a blocked door or exit could cause grave personal injury in case of emergency evacuation of a building. Do not store flammable materials, such as paint or thinners, next to buildings. Preferably, these should be in closed containers, in a shelter detached from the building. Warning signs must be so posted that personnel are aware of areas where flammable materials are stored. Do not store materials of any type on the roof of a building.

Roads and grounds. Do not allow grass or weeds to grow excessively near buildings or access areas. Such growths greatly increase the possibility of fire. Pick up objects on the ground which could cause personal injury or equipment damage during mowing or cleanup operations.

Good outside lighting is an important factor in housekeeping. Roads, walks, stairways, and grounds must be kept well lighted so that all permanent obstructions may be avoided and temporarily out-of-place objects may be removed.

Exercises (086):

1. Who is held primarily responsible for unsafe conditions caused by poor housekeeping practices?
2. What is the best way to insure good arrangement of work areas?
3. Cite the method of storing scraps and waste temporarily.

4. What dangers are there in failure to clean up drips and spills?
5. List four main areas of concern in interior housekeeping.
6. What are the main areas of interest in outdoor housekeeping?
7. How might an accident be caused by storing materials under an outside stairway?
8. What hazards are created by excessive growth of grass and weeds near buildings or access areas?
9. What is the importance of good outdoor lighting?

087. Name the four main classifications of fires and a typical fuel for each.

Classification of Fires. Fire is a chemical reaction between a combustible material and oxygen. To produce fire, three things must be present at the same time: fuel, heat, and oxygen. If any one of these three is missing, a fire cannot start. With the removal of any of them, the fire will extinguish. Fire extinguishers, usually hand-operated and portable, are designed to remove one or more of the three elements of combustion from interaction with the others. In their purpose, fire extinguishers are like first aid, intended only for emergency use during the initial stages of the fire, as shown in figure 7-2.

Fires are grouped into four general classes, each of which can be extinguished by a particular action or agent. Because all fire extinguishing agents cannot be used on all types of fires, this classification makes it possible to determine and use the agent best suited for fighting a particular type of fire.

Wood, paper, or rags. Water, or chemicals in water solutions, are used to control and quench fires involving wood, paper, or rags. Water acts to cool the combustibles; thus, eliminating the heat

required for combustion. Fires of these combustibles are of class A.

Flammable liquids. Fires which occur in flammable liquids, such as fuels, solvents, greases, or similar substances, are of class B. The agents required for extinguishing this type of fire are those which will dilute or eliminate air by blanketing, thereby creating a smothering effect.

Electrical. Fires occurring in electrical equipment are usually fueled by insulating materials or certain plastic compounds. These materials will usually smolder or smoke rather than produce open flame. The extinguishing agents used on this class of fire are nonconductors of electricity and work principally by smothering the fire. This type is of class C.

Combustible metals. Fires that occur in combustible metals, such as magnesium, potassium, powdered aluminum, zinc, or sodium, are class D fires. Dry powder extinguishers will be used on all class D fires.

Exercises (087):

1. Name four general classes of fires.
2. Name three things that must be present to produce fire.
3. For each of the four general classes of fires, give one or more examples of the fuel typically involved.

088. Associate fire extinguisher types and classes of fires and distinguish true from false statements about handling fires, correcting the latter.

Use of Extinguishers. To extinguish a fire, you must remove one of the three fire-producing factors. You starve, smother, or cool a fire to extinguish it. If you cut off the supply of fuel from a fire, you starve it. You smother a fire when you remove oxygen (air) from it. Use of foam, carbon dioxide, and sand produces smothering. You cool a fire when you remove heat from it, normally by putting water on it. Some water extinguishers use a gas cartridge (CO₂) to provide extra pressure. But, remember that you use water on class A fires only; water will make a petroleum fire spread. Also, never use water on electrical fires, because water conducts electricity, and you could be electrocuted. NOTE: When extinguishing a fire, always place the extinguisher upwind of the operation.

CLASSES OF FIRES

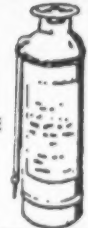
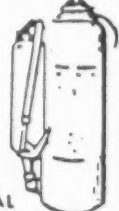
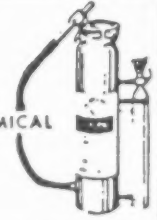
ORDINARY  COMBUSTIBLES GREEN TRIANGLE	 CLASS A FIRES WOOD PAPER TEXTILES, ETC	 FOAM OR SODA-ACID	 WATER PUMP	 GAS CARTRIDGE	 OTHER TYPES MAY HELP ON SMALL CLASS A FIRES
FLAMMABLE  LIQUIDS RED SQUARE	 CLASS B FIRES OILS GREASES PAINTS	 FOAM	 VAPORIZING LIQUID	 CARBON DIOXIDE	 DRY CHEMICAL
ELECTRICAL  EQUIPMENT BLUE CIRCLE	 CLASS C FIRES LIVE ELECTRICAL EQUIPMENT	 VAPORIZING LIQUID	 CARBON DIOXIDE	 DRY CHEMICAL	USE THE RIGHT TYPE FOR EVERY FIRE
COMBUSTIBLE  METALS YELLOW STAR	 CLASS D FIRES SOLID METAL POWDERED METAL METAL CUTTING	 G-I POWDER	 DRY POWDER	NOTE: NORMAL DRY CHEMICAL AGENTS MAY NOT BE EFFECTIVE ON CLASS D FIRES. DO NOT ATTEMPT TO USE EXCEPT AFTER THOROUGH TRAINING.	

Figure 7-2. Classes of fires.

Figure 7-2 shows several types of fire extinguishers. You may use some of these on more than one class of fire. Therefore, study figure 7-2 carefully; learn which extinguishers to use on each class of fire.

Foam is often used on petroleum fires. Since it is lighter than petroleum products, it floats on top of the fuel and thus smothers the fire by cutting off the oxygen. Again, though, never put foam on electrical equipment, because it contains water, and water conducts electricity. To use a foam extinguisher, grasp the hose, turn the extinguisher, grasp the hose, turn the extinguisher upside down, and direct the foam against a wall, the side of the tank, or the ground so that the foam will gently spread back over the burning surface. You may also throw the stream of foam high so that it arches onto the surfaces and gently spreads. Once you invert a foam extinguisher, it can't be stopped. Foam will flow until all of it is gone, even if you turn the extinguisher right side up.

Dry chemical extinguishers are good for putting out fuel fires at homes of tank cars or tank trucks. These dry chemical extinguishers contain bicarbonate of soda, which is released when a turn of a handwheel punctures the inner cartridge of carbon dioxide or nitrogen. This action releases both a smothering gas on the fire and a cloud of dry chemical, which shields the operator from the heat. Dry chemical is also excellent for putting out electrical fires.

Carbon dioxide (CO_2) is a gas about one-and-a-half times heavier than air. When CO_2 is discharged, its vapors look like snow. It acts both to smother and to cool. NOTE: Keep your hand off the CO_2 extinguisher discharge horn, because the horn becomes extremely cold, and your hand may get frostbitten. When you use the CO_2 extinguisher, grasp the carrying handle and place the extinguisher on its base in the upright position. Remove the horn from its bracket, and hold the discharge hose by its wooden or rubber handle to prevent frostbite. Turn the valve counterclockwise; or squeeze the handle, if a grip type valve is used. Direct the carbon dioxide at the base of the flame and slowly work from side to side. Advance the discharge as the flame is extinguished. Don't direct the CO_2 too high or haphazardly over the flame. You could suffer a flashback.

Chlorobromomethane is used in a vaporizing liquid extinguisher. Commonly known as CBM, the chemical has a sweet, chloroformlike smell. It is both unstable (volatile) and poisonous. If CBM enters your eyes, flush them with plenty of water and get a doctor at once. Also, handle this kind of extinguisher only in well-ventilated areas. Furthermore, work upwind and wear a mask type respirator.

Sand (or dirt) can be used to put out small petroleum fires if you don't have a better

extinguisher. Sand creates a blanket that smothers the blaze. You may also use sand to cover small fuel spills. However, in case of large spills, call the fire department.

In using dry powder, don't get this type of extinguishing agent confused with dry chemical fire extinguishers. Dry powder is used to smother fires that are found on combustible metals, such as magnesium. Another agent that is used on combustible metals is G-I power. This is a graphite powder that is scooped from a pail or bucket. This, again, smothers the flame.

You have learned that different extinguishers use different chemicals to control fires. Always place a fire extinguisher to take advantage of the wind; that is, upwind of the fire so that the flames will be blown away from you.

Exercises (088):

- Match each type of fire extinguisher given in column B with the classes of fires on which it can be used, found in column A, by putting each numbered type (column B) beside its related class(es) (column A). NOTE: Each item in column B may be used once or more than once.

Column A	Column B Classes of Fires
___ a. Dry chemical.	1. Class A fires.
___ b. Water pump.	2. Class B fires.
___ c. Carbon dioxide.	3. Class C fires.
___ d. Foam.	4. Class D fires.
___ e. Gas cartridge.	
___ f. Soda-acid.	
___ g. Vaporizing liquid.	
___ h. Dry powder.	

- Among the following, identify true statements with T and false statements with F, correcting each false statement.
 - ___ a. A fire is starved when the oxygen has been removed.
 - ___ b. A water pump fire extinguisher is generally used to smother a fire.
 - ___ c. A fire is starved when the fuel source is cut off.

- d. A carbon dioxide fire extinguisher cools a fire.
3. Identify a limiting factor of each of the following types of fire extinguishers.
- a. Carbon dioxide.
 - b. Foam.
 - c. Vaporizing liquid.
 - d. Water.

089. Clarify selected hazards resulting from the use and storage of solvents and lubricants and specify the safety precautions they make necessary.

Hazards of Solvents and Lubricants. The hazards inherent in handling and being exposed to solvents and lubricants are many. For example, damage to vital organs may be caused by absorption of the toxic agent into the blood stream through prolonged breathing of vapors or by direct skin contact. Some problems which can result are liver or kidney damage, respiratory ailments, or central nervous system depressions. Additionally, acute or chronic skin disorder may be caused, depending upon the type of agent used. Some solvents remove natural oils and fats and cause the skin surface to become dry, hard, and broken. This last result may also open the skin to bacterial infection.

There are a number of hazards associated with solvents and lubricants during their storage and use. Some of these are classified as health hazards and others as accident causes.

Mishandling of solvents and lubricants may also result in fire or explosion. This is particularly true in the case of lubricants or when the wrong type of solvent is used.

Storage precautions. Solvents and lubricants can be so stored that health and accident hazards are minimized. Whatever the type of solvent or lubricant used, store only as much as you need until you get your next requisition. Use only approved containers and store them in areas where they will not be subjected to excessive heat, sparks, or flame. Some solvents, while not actually volatile, will build up extreme pressure inside a sealed

container when subjected to heat. This may cause a container to rupture, spraying or splashing the contents on personnel or equipment. This is particularly true of material contained in aerosol spray cans. In addition, lubricants leaking from a faulty or unsealed container may readily ignite when in an area where they are exposed to sparks or open flame. Remember, use care in the manner and selection of the area in which you store solvents and lubricants.

Safety measures. As we have mentioned previously, only approved and authorized solvents will be used for cleaning equipment. Under most circumstances, solvents having suitable cleaning characteristics will already have been selected for use in your maintenance area. To get the job done, the solvent should clean and degrease thoroughly, leave little or no residue, and cause no deterioration of components or insulation. To get the job done SAFELY, the solvent must also be nonvolatile, nonflammable, and as nontoxic as possible. Normally, solvents which are flammable or volatile will NOT be used.

When opening the solvent container, be careful to avoid splashing or spraying the contents into yours or another's eyes or onto any skin.

Avoid breathing the vapors or fumes of solvents; especially avoid any prolonged exposure. Only use these solvents in well-ventilated areas, so that there is no concentration of the fumes. Some type of exhaust ventilation is necessary if solvents are used on a continuing basis. A work area where cleaning solvent is used must be inspected periodically by a bioenvironmental engineer or qualified medical specialist to insure that ventilation is adequate. In addition, personnel who are exposed to certain types of solvents on a continuing basis are required to have a periodic examination. This need is determined by base medical personnel according to the type of solvent used and the frequency of exposure. If your work area has a cleaning facility using bulk amounts of solvent, base medical personnel may be contacted for a determination as to whether or not such a physical examination is necessary.

If aerosol solvents are used, follow the directions carefully. Make certain that you spray the solvent only where needed and only in the amount necessary. Make certain co-workers are not in a position to be contacted by the solvent. When using bulk solvents, as in open containers or pans for bathing parts and assemblies, wear protective gloves.

Exercises (089):

1. State two precautionary measures you will follow when using cleaning solvents.

2. From a safety standpoint, solvents should be as _____ as possible, and must be _____ and _____.
3. Give two ways in which toxic substances may be absorbed into the bloodstream.
4. The defatting effect of solvents may cause the skin to dry out and break open, increasing the possibility of _____.
5. What general precautions should be used in storing solvents and lubricants?
6. Describe briefly the possible consequences of storing a sealed container of nonflammable solvent in an area next to a water heater element.

090. Cite specific hazards present and precautions required when working with electricity.

Hazards of Electricity. The wide use of electronic equipment in almost every Air Force maintenance area exposes personnel to many accompanying dangers. Poor judgment in the use and maintenance of electronic equipment and electrically powered tools is one major cause of injuries and equipment damage. Pneumatic personnel are constantly exposed to the dangers of severe electrical shock and burns that result from contact with "hot" circuits. Short circuits, overloading, accidental grounding, poor electrical contacts, and misuse of equipment are all sources of the major accidents involving electricity. By observing the safety precautions discussed here, you can minimize the danger of electrical shock.

Precautions. Almost all electronic equipment has dangerous voltages. Before working on such equipment then, be sure that it is turned off and that it can't be turned on accidentally.

Don't wear metallic objects such as rings, identification tags, medals, wristwatches, glasses with metal rims, or bracelets when working near any electrical potential.

Don't bring metallic measuring rules, metal cased objects, or metal tools near energized electrical circuits.

Don't depend upon friction or rubber tape on the handles of tools, to prevent electrical shock. Avoid

using screwdrivers with wooden handles, since the wood can absorb moisture. Always use screwdrivers with rubber or plastic handles when working around electricity.

Keep the area surrounding high-voltage equipment clear of all obstructions, such as tools, toolboxes, and other foreign objects.

Be sure to learn the location of the main power switch. If someone contacts a live circuit, or if something in the equipment starts to smoke, **PULL THE SWITCH!** But, never close a switch unless you know what is connected to the circuit involved.

Exercises (090):

1. State the major cause of accidents and injury when working with electronic equipment.
2. List five hazards responsible for accidents involving electricity.
3. State the first precaution you should take before working on electronic equipment.
4. Give the precaution required before working near an electrical potential as regards any metallic objects you may be wearing.
5. When working on electrical equipment, why should wooden handled screwdrivers be avoided?
6. State the required precautions regarding main power switches.

091. Identify the dangers of compressed air and/or nitrogen over compressed air.

Compressed air and its hazards and nitrogen and its hazards, in that order, are our topics in this LO.

Compressed Air and Its Hazards. Although compressed air is used in many different ground maintenance operations daily, few persons realize the dangers associated with its handling and use. Serious injuries have been caused by using compressed air to blow dirt or dust from work clothes or by using it to clean up filings, chips, and

shavings from repair jobs. Air pressure strong enough to clean dust or dirt is also strong enough to injure a person's eyes and ears and to penetrate his body. Pressures as low as 10 to 15 psi have been known to cause serious injuries. It has been estimated that a pressure of only 4 psi will rupture the intestines. Compressed air must be handled with care. When compressed air is being used, you should be careful to keep foreign objects from entering the equipment. Not only can this damage the equipment, but personnel can be injured by small objects blown out of nozzle openings. If a hose is not attached or held, it could whip around like a snake when the air pressure is turned on and strike personnel or equipment, inflicting extreme damage. While servicing any component such as air bottles or landing gear struts, you should be careful not to overinflate these components. You should use pressure regulators to regulate the pressure. Prior to use, the air lines and connections should be inspected for defects. Air pressure can be compressed so, if you are servicing an air bottle or accumulator, you are putting volume in the container. If the container was to crack, the volume of air would cause the container to explode like a bomb.

Nitrogen and Its Hazards. The atmosphere is the body of gases surrounding the earth, and it is composed, by volume, of approximately 78 percent nitrogen, 21 percent oxygen, and 1 percent other gases. When we say that we are going to service a unit with dry compressed air, we mean that we are going to service it with 78 percent nitrogen, 21 percent oxygen and 1 percent other gases. Alone, oxygen is noncombustible but it will support combustion. In fact, it must be present for a fire to burn. Hydrocarbons can be defined as any liquid or solid composed of carbon and hydrogen. Aircraft oils and gasolines are good examples of hydrocarbons. If hydrocarbons come into contact with oxygen an explosion may occur. (NEVER SERVICE A PNEUMATIC UNIT WITH OXYGEN.) Nitrogen, on the other hand, is an inert gas (will not support life or combustion). Nitrogen can be extracted from the atmosphere and stored in bottles. Because of this, pure nitrogen would have less moisture content than does compressed air. This is important, because the less moisture content, the less chance of corrosion.

Nitrogen bottles are gray and come in two types. The first type is oil-free nitrogen (water pumped). It can be recognized by two 3-inch black bands around the shoulder of the cylinder. The second type is oil-tolerant (oil pumped). It can be recognized by one 3-inch black band around the shoulder of the cylinder. Also the word "nitrogen" is usually printed on the side of the bottle. When we say "water-pumped nitrogen," we mean that the nitrogen is compressed with a water-lubricated pump. In contrast, oil-pumped nitrogen uses an oil-

lubricated pump. When using nitrogen, be sure to use the type of nitrogen specified in the TO.

Nitrogen is colorless and odorless. Consequently, we would not be aware of the degree of its concentration in a closed compartment, nor would we be aware of a commensurate lack of oxygen. But remember, we said that nitrogen will not—by itself—support life. Thus, if we were to breathe nitrogen in heavy concentrations, it would cause oxygen starvation. The lesson is this: when storing or using nitrogen, be sure to have proper ventilation.

Exercises (091):

1. What is the minimum pressure required to rupture the intestines?
2. Explain how compressed air stored in air bottles is dangerous.
3. What is the prime reason for using nitrogen over compressed air?
4. What type of nitrogen is indicated by one black band?
5. If nitrogen is stored in a small room, what could be the danger if the bottle were to leak?

092. Specify safety precautions to be observed while carrying and unloading materials and equipment.

Handling Procedures. Before you try to lift that box of equipment, there are some preliminary checks that you should make. Be sure that you have removed all of your jewelry and are not wearing loose clothing. Check the route you will be taking to see that the floor is free of water, grease, or any other slippery substance. Inspect aisles and stairways for any obstructions that might cause you to stumble. Also, inspect the object to be lifted for slippery substances on its surfaces, any protruding nails or screws, and splinters. Finally, you should wear gloves at all times when you unload equipment.

Frequently during your assignment, you will be involved in unloading equipment from a vehicle.

Although this may seem a very menial part of your overall job, it is important too, because of the hazards it presents. In recent years, the injury problem in the Air Force caused by the manual handling of equipment has become acute. This increase is almost entirely due to poor handling practices. Therefore, review some of the common sense precautions which you should follow; these are given next.

When you lift the object, grasp it in such a manner that you can control it, should it become unbalanced. If the object is to be lifted from a level lower than your waist, you should lift it as demonstrated in figure 7-3. Assume a squatting position, with your back straight, and allow your legs to exert the primary lifting force. Use the reverse of this method to set the object down. Be particularly careful when releasing the object in order to prevent injury to your fingers, hands, and feet.

Personnel considerations. Physical differences in personnel is an important factor in the unloading process. Safe lifting limits vary for all individuals; however, a good rule of thumb is 50 pounds for male personnel and 25 pounds for female personnel.

If you have an object that is too heavy for you to handle safely, be sure to ask for help. Select

someone who is close to your height so that the load may be carried evenly. Before you start carrying the object, decide on the route you are going to take and arrange an emergency signal should it be necessary for either of you to release the load suddenly. As you begin to walk, stay in step. This will make it easier for the two of you to coordinate your movements and to carry the object safely and smoothly.

If the load is too heavy or bulky for two people to carry safely, then use a handtruck or forklift. When these are used properly, these mechanical aids can simplify handling and reduce the hazards connected with moving large objects.

Exercises (092):

1. You have been instructed to unload equipment from a truck. What are the initial precautions you should take?
2. What position should you assume to lift an object from a level lower than your waist?



(A) WRONG



(B) RIGHT

42-1536

Figure 7-3. Handling material.

3. What precautions should be followed when more than one person is needed to carry an object?

7-2. Flight-Line Safety

As you work on the various aircraft in the Air Force inventory, you will come upon many unusual safety situations that will not be familiar to you. For this technical orders exist to explain how or why these systems perform in the way they perform. We cannot possibly explain all of the safety procedures to follow for each aircraft in this small section. Therefore, we have selected some of the more common safety hazards you will be coming into contact with on the flight line. Some of these are high-frequency radiation, noise hazards, jet engine dangers, and cockpit area hazards.

093. Examine the hazards of nuclear radiation by identifying the types and their effects and providing selected details about required protective devices and precautions.

Radiation. The final form of destruction resulting from atomic explosion or exposure to contaminated equipment is nuclear radiation. This radiation consists of alpha, beta, and gamma rays.

Alpha radiation can be stopped by almost any barrier, including an inch or two of air. It becomes a hazard only if the material is taken into a person's body by breathing, by eating or drinking contaminated food, or by entry through broken skin surfaces.

Beta radiation has a range of a few feet in air and very little penetrating power. However, it may inflict severe burns on the unprotected skin or may cause internal damage if ingested into the body. It can be stopped by such barriers as ordinary clothing; however, protective clothing should be used when you are working in a contaminated area. Like alpha, beta can damage tissues when taken internally. Protective clothing and respirators are the only protection needed for either the alpha or the beta rays.

Gamma radiation can never be absorbed completely by any barrier. For this reason, it is the most deadly hazard to consider during any decontamination procedure. The intensity of the radiation is monitored by trained personnel. This intensity is expressed as a quantity of radiation per unit of time. The quantity unit of measure is the roentgen, (Ren-can) and the time unit is the hour; thus, intensity is expressed in roentgens per hour (R/HR).

When working on or near contaminated equipment, you will therefore be under the

supervision of medical personnel. Wear a film badge, or dosimeter, so that the amount of radiation (dosage) you receive can be measured. This is put into your medical records. You will not be allowed to collect too large a dosage. After working on a contaminated aircraft, take a shower immediately. Then check to see that you have removed all of the radiation particles. If you are free of radiation, dress in clean, contamination-free clothing. Waste materials from cleaning contaminated equipment is disposed of by burial. This is done away from any maintenance activity.

Although nuclear radiation is the least likely hazard met on the flight line, still it may exist in the event of an accident while handling a nuclear weapon. It may also exist if an aircraft carrying a nuclear weapon should crash. Another possibility is that one of our planes may fly through a contaminated zone, and upon its return, need repair.

Radiation is invisible. We have only one way to show the presence of radiation, and that is by placing radiation placards in the area. Study the symbol in figure 7-4. Learn its shape and colors, magenta (reddish purple) on a yellow background. It may save your life.

Exercises (093):

1. List the types of nuclear radiation.
2. Identify the type of radiation that can be stopped with an inch of air.
3. Which type of radiation can be stopped by ordinary clothing?

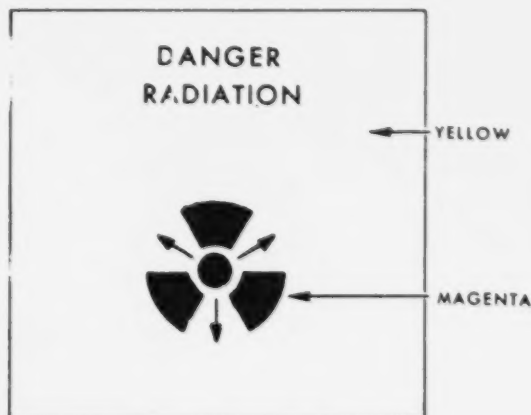


Figure 7-4. Radiation placard.

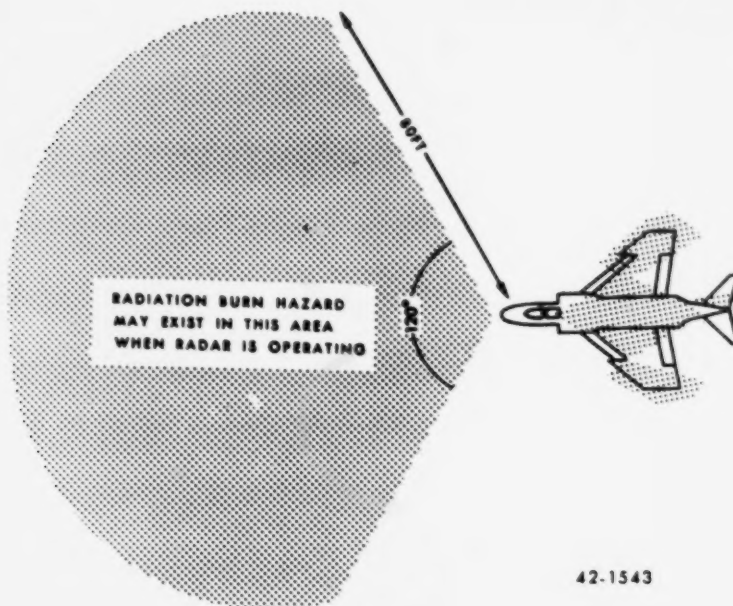
4. Which radioactive force is considered the most deadly?
5. How is the intensity of radiation expressed?
6. When are alpha and beta radiation particles considered hazardous?
7. What type of device is required to be worn when working near contaminated equipment?
8. List the conditions where nuclear radiation could be encountered on the flight line.
9. Describe briefly the appearance of a radiation placard.

094. Examine the hazard of radio-frequency radiation by giving the sources and their effects and identifying a specific precaution and protective device related to such radiation.

Radio-Frequency Radiation. We must now mention dangers beyond our normal ability to see or hear. These are called "radio-frequency transmissions." "Electromagnetic radiation" is another name applied to this hazard. This radiation is given off by high-frequency radio transmitters, radar, or electronic countermeasure devices. The particular hazard is often hidden behind the visor or radome of an aircraft. The energy radiated by these transmitter antennas can cause flashbulbs to ignite and steelwool to burn. (See fig. 7-5.)

Radio-frequency radiation can cause burns beneath your skin and cataracts over your eyes. Yet, as we have said, the presence of this energy may not be apparent. The injuries may occur before any pain is felt. When electromagnetic energy is absorbed within the body's tissues, heat is produced. If the heat cannot be dissipated as fast as it is produced, the internal temperature of the body will rise. Internal organs are not cooled by an abundant flow of blood. Therefore, these organs can be damaged easily by heat from excessive exposure to radiation.

To avoid this danger, don't stand in the beam of a nearby radar antenna; you cannot tell whether or not your internal organs are being heated, and you



42-1543

Figure 7-5. Radio-frequency radiation.



Figure 7-6. Radio-frequency radiation warning sign.

could suffer serious damage before you are aware of it. In fact, wherever possible in a maintenance situation, avoid the area of radiating power from radar antennas. You can determine this area by the warning sign shown in figure 7-6.

If it is not possible to safely radiate the power or to couple it into a dummy load, use a radiation absorption screen. Radiation hazards depend upon a great many variables, such as time of exposure, strength of emission, weather, and the number of units operating in the area. Common sense, good judgment, and experience must be used to evaluate these variables.

Exercises (094):

1. List three sources of RF radiation.
2. What are the principal effects of RF radiation on the human body and vital organs?
3. What basic precaution can you take to avoid exposure to RF radiation?

4. What protective device may be used for partial protection against RF radiation?

095. Clarify cockpit safety by citing hazardous cockpit conditions and describing escape module ejection in advanced aircraft and the danger in leaving tools in aircraft.

Cockpit Safety. The cockpits of fighter and bomber aircraft have always presented a hazardous condition to maintenance personnel. The greatest hazard is due to the explosive charges which eject the canopy and seat. Accidental firing of ejection seats and canopies can result in serious injury to personnel as well as severe damage to the aircraft. Therefore, as a safety precaution, seat and canopy ground safety pins with streamers are installed immediately after each flight and will remain installed while the aircraft is on the ground. For this, see figure 7-7. Consequently, when working close to ejection seat catapults or canopy remover controls, be particularly careful to avoid accidental arming and firing, since extreme heat or unintentional movement of the actuating mechanisms can fire the ejection seat catapult or

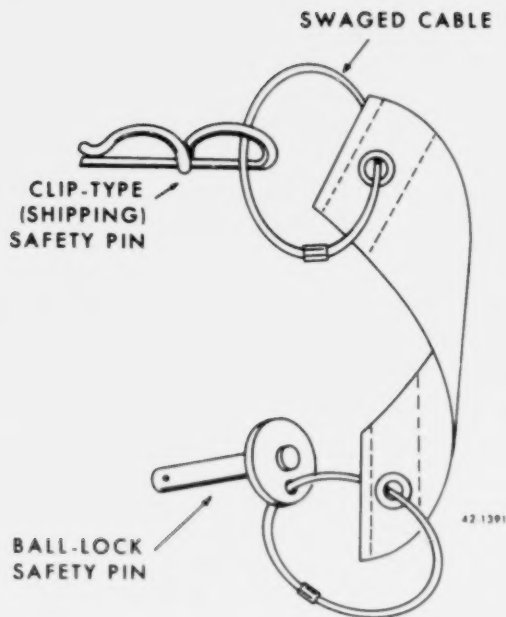


Figure 7-7. Typical safety pins.

canopy remover. You can identify the ejection seat by a warning sign, usually painted on the side of the aircraft, as shown in figure 7-8.

These systems command the same respect from maintenance personnel as does a machinegun or an aircraft cannon, since—indirectly—the catapult and remover are types of firearms. The catapult containing the ejection seat explosive charge is capable of hurling 300 pounds at an initial rate of 60 feet per second.

Although the previous information is true regarding most of the fighters and bombers in today's Air Force, the construction of advanced aircraft presents an entirely new and different type of hazard as related to the cockpit.

Some newer aircraft have an ejectable crew module for escape purposes. The crew module forms an integrated portion of the forward fuselage. The entire module is ejected from the aircraft. Ejection is accomplished by firing shielded mild detonating cord (SMDC), which in turn fires guillotines. The guillotines sever control cables, oxygen lines, antenna leads, etc., which enter the capsule. The SMDC also fires splice plate explosive severance strip charges, which sever the module from the aircraft. Finally, the SMDC ignites the rocket motor to separate the module from the remainder of the aircraft. Several compartment covers on the module contain explosive charges. The greatest hazard resulting from inadvertent firing of the escape system is due to flying debris or

pieces of metal. Compartment covers and pieces of metal from the severance strips are propelled in random directions to a distance of up to 100 feet. The second hazard results from the rocket blast when the rocket motor is ignited. The blast is directed downward and exists underneath the aircraft. Severe burns could result to anyone underneath the aircraft should the ejection system be inadvertently activated.

You should also watch out for and avoid the disease known as "switchitis." No, you won't find this word in the average dictionary. It is a flight-line term that describes a person who just *has to turn* every switch or lever he sees in order to find out what will happen. If this fits you, you may be in for an unexpected ride or shock of your life. Look at figure 7-9 in connection with this danger, and *never pull a handle or flip a switch if you do not know what the results will be*. Remember, the modern aircraft cockpit is deadly in the hands of the inexperienced. The reason, of course, is that the cockpit contains controls for explosives, wingtip tanks, canopies, flaps, and landing gear controls—all of which are "killers." Also, be aware of other people working on the aircraft. This is especially important if electrical or pneumatic power is applied. If you accidentally hit the wrong switch at the wrong time, someone could be hurt seriously. So, if you ever feel "switchitis" coming on, stop what you are doing and ask someone else what "that switch" does.

Lastly, consider the hazards involved in tools and debris left in the cockpit. Obviously, loose tools and debris left here can cause serious personal injury and equipment malfunctions. For example, a wrench, screwdriver, or other debris littering a cockpit can jam a control, or it could unexpectedly come flying out and strike the pilot or the instrument panel later, when the aircraft is performing maneuvers. Therefore, when you work in an aircraft cockpit, check to be sure that you have all of your tools and equipment before you leave. You could use a locally prepared checklist of each tool and object carried in a toolbag to insure that your shop is never responsible for foreign object damage (FOD).

Exercises (095):

1. What is the greatest cockpit hazard present on most fighter or bomber aircraft?
2. How is module ejection initiated on the advanced fighter or bomber?

3. List the ejection hazards present on the advanced fighter or bomber.
4. What precaution should you take if you are required to perform maintenance in or around the cockpit?
5. What does the term "switchitis" mean?
6. Describe briefly what can happen if a tool is left in the cockpit.

096. List danger areas and conditions around an aircraft when the engines are operating and cite selected hazards and safety procedures.

Topics in this LO are jet engine dangers, reciprocating and turboprop engine dangers, and foreign object damage—in that order.

Jet Engine Dangers. The operation of jet engines constitutes a major source of another group of hazards that you must be aware of when working on the flight line. The major danger areas here are: (1) the intake, (2) the engine exhaust, (3) the engine turbine plane, and (4) the cartridge starter plane. The noise level is also a significant danger in that it ultimately will reduce the acuteness of a person's sense of hearing.

There have been instances when the turbine wheel has disintegrated in operation. If this happens while you are standing in the plane of rotation, you may be cut to pieces by flying parts traveling at speeds far above the muzzle velocity of a rifle. For this reason, always stand fore or aft of the plane of rotation when the engine is being operated on the ground. To make this danger area easy to locate, a painted RED stripe may mark the danger point on the aircraft. If there isn't a red stripe, you should check the applicable technical order to determine exactly where the plane of rotation of the engine turbine is located. The cartridge starter, another danger, is essentially a

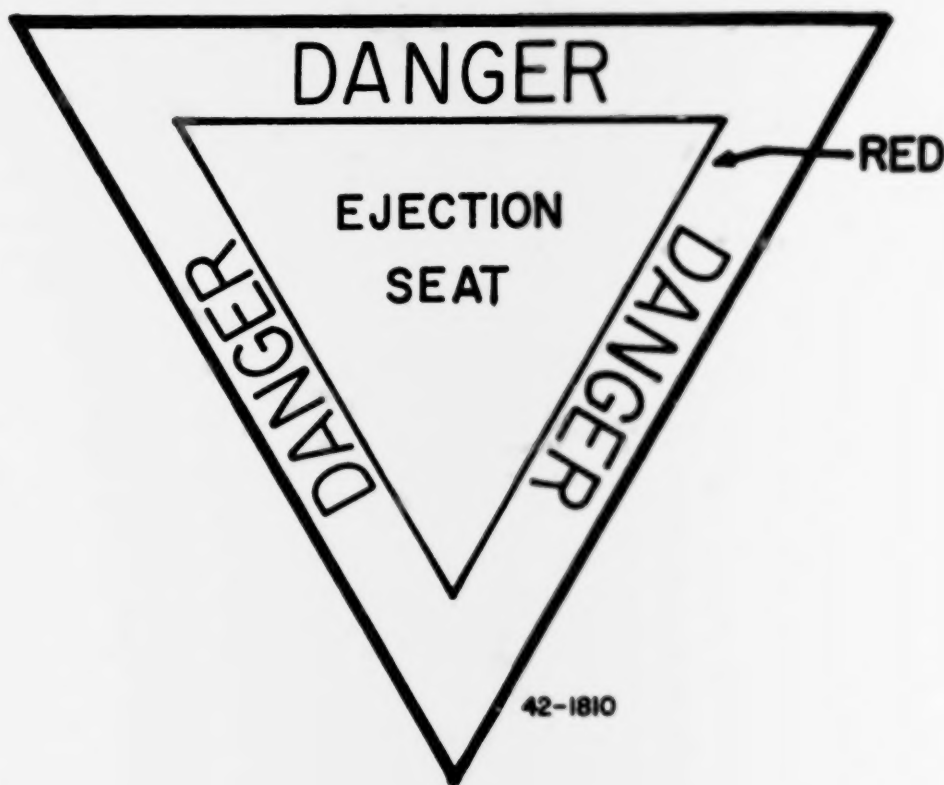
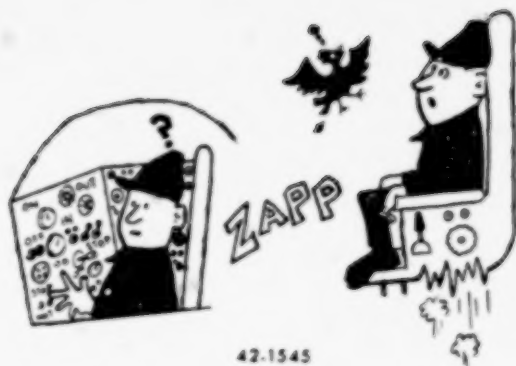


Figure 7-8. Ejection seat warning sign.



42-1545

Figure 7-9. Switchitis.

small turbine which is rotated by the blast from a high-powered cartridge. The danger area is normally 200 feet in the plane of rotation on either side of the aircraft.

Two sources of very serious injury and very often fatalities are the exhaust blast areas and the engine intake. Study figure 7-10 in this regard. These two areas really require your class attention. The high velocity and high temperature of the jet engine's exhaust blast make it particularly hazardous to personnel; it is to be carefully avoided. A safe distance is considered to be about 200 feet to the rear for most aircraft, but the exhaust blast area is not the same for all aircraft; so check the applicable technical order on the aircraft with which you are working.

The suction effect of an operating jet engine intake is sufficient to cause fatal injury to personnel and extensive damage to equipment. A safe distance from these intake ducts is normally 25 feet to the front and sides of the duct. On some of the more advanced aircraft, the technical order cautions that danger also exists in an area that extends to 4 feet aft of the intake lip, when the engines are operating at high power settings.

To aid in preventing accidents involving engine intake ducts, never wear loose clothing or carry objects that might be drawn into the intake.

Reciprocating and Turboprop Engine Dangers. To some, propeller-(prop) driven aircraft may seem outdated, but they are not, and we do have to work around them. One area that you need to stay clear of is the propeller. Some people have had their heads split open by them. People have a tendency to walk through the blades when the aircraft is shut down, like when it is in the docks. This may seem harmless, but habits are formed this way, and one day you may try it on the flight line. Consider, for example, walking through the prop just when some one decides to start the engine, or walking through a prop just after an engine has been shut down. **WARNING:** A hot engine can "tick over" just enough to cause the prop to spin just as you are passing through it. Also, beware of the hypnotic effect of a rotating propeller; this may cause you to walk into it while it is rotating. Therefore, do not stand within 25 feet of the front of a rotating propeller.

How many times have you heard the story of the supervisor sending a 3-skill-level specialist out to get a gallon of "prop wash?" The young specialist is

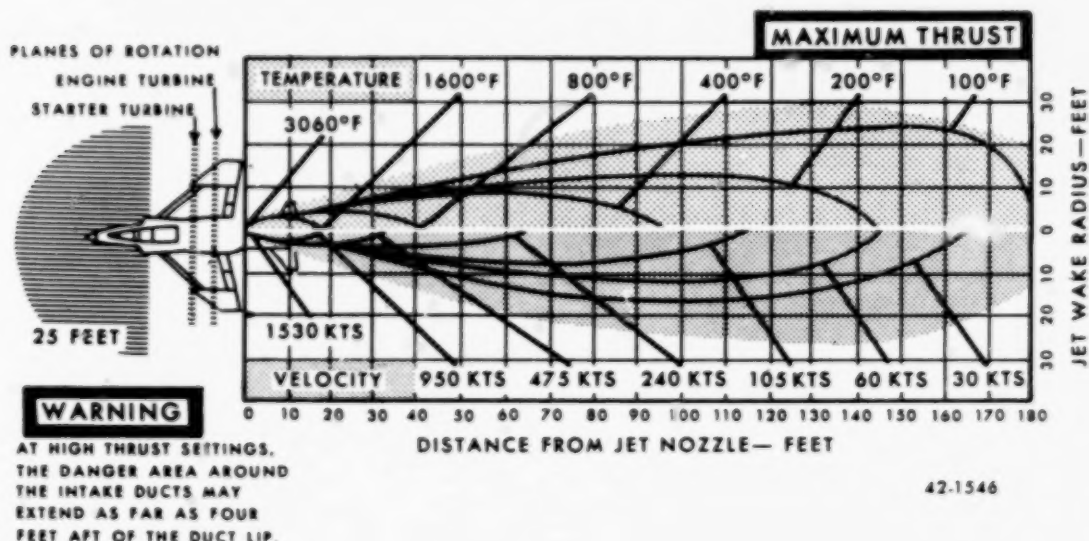


Figure 7-10. Jet engine dangers.

sent from one section to another until he eventually comes to the conclusion that there is no such thing. This is, of course, not true. There is such a thing as prop wash, and it can be dangerous. In fact, propeller wash can be compared to a giant fan. It has often thrown dirt and other particles into people's eyes, turned over equipment, or blown away books, papers or other debris, which all add to the FOD. (foreign object damage) on the flight line.

Foreign Object Damage. Foreign object damage is the term used to describe any foreign object that doesn't belong where it is, such as nuts, bolts, washers, tools, cotter pins, safety wire, stones, or rags. FOD could or possibly has caused damage to aircraft. It is an ever-present hazard to the operation of jet engines. Therefore, all maintenance personnel must exercise extreme care while performing maintenance in and around the aircraft in order to prevent foreign object damage to the engines. The large size of the newer jet engines creates higher suction pressures that enable the

engines to pull objects from greater distances into the engines. Therefore, it is mandatory that personnel performing maintenance on aircraft account for all tools, hardware, and components after maintenance has been accomplished or before engine runup. See figure 7-11 as it relates to FOD problems. Numerous engines have been completely demolished because someone failed to police the runup area or engine intakes for FOD before the engines were started.

Exercises (096):

1. List the major danger areas that exist around a jet aircraft.
2. Why is the plane of rotation of the engine turbine wheel considered dangerous?

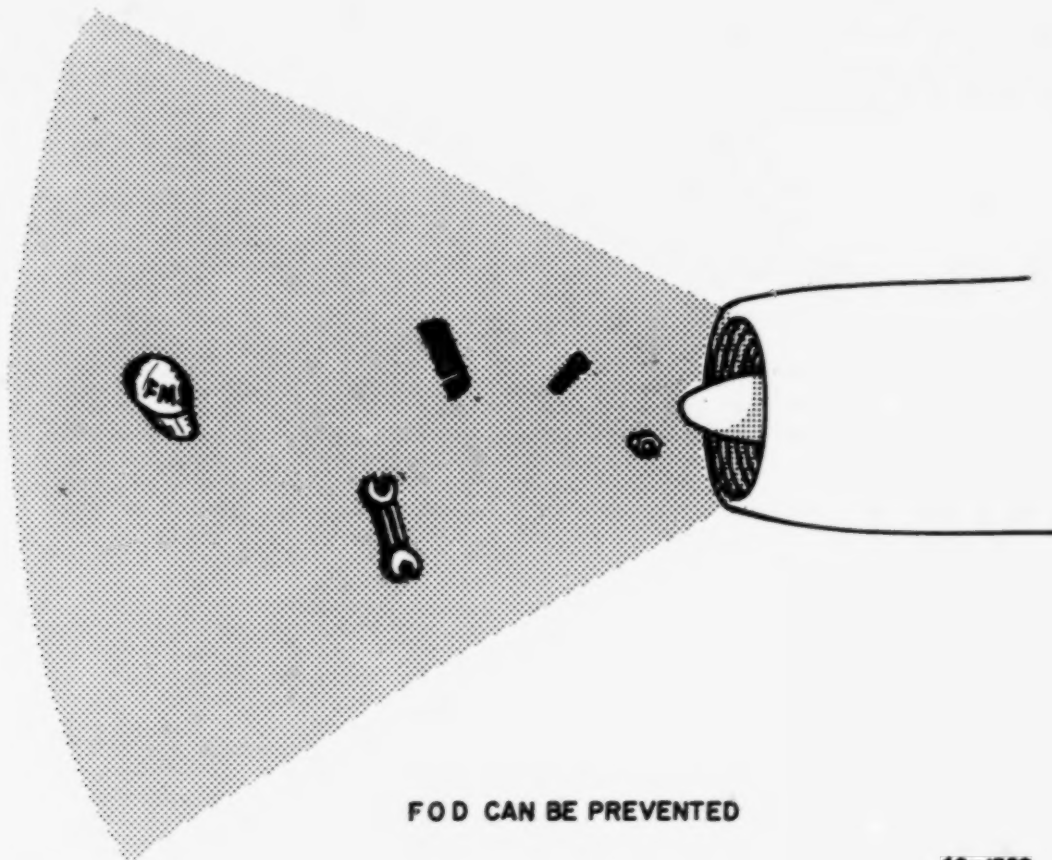


Figure 7-11. FOD can be prevented.

3. State the way in which you can determine where the plane of rotation of the engine turbine is located.
4. What conditions make the engine exhaust most particularly dangerous?
5. How would you determine the safe distance behind an operating jet engine?
6. What condition causes the danger area around an operating jet engine intake?
7. What is normally considered a safe distance from an operating jet engine intake?
8. What does FOD mean?
9. What should be done after all maintenance has been accomplished or before engine runup?
10. List the major danger areas that exist around a reciprocating engine aircraft.

097. Identify high-intensity sound areas and list protective measures to take when working around operating jet aircraft engines.

High-Intensity Sound. When around aircraft you are exposed to extremely hazardous noise potentials. Such noise endangers a person's hearing and interferes with speech communications. It also leads to fatigue. Fatigue in turn leads to faulty maintenance, causing an increase in number of accidents attributed to "maintenance errors." As a result, there is a general increase in the number of ground accidents.

The loudness or intensity of sound is measured in decibels (db). The (db) scale is based on a rather complicated comparison or ratio among sound intensities. Refer to figure 7-12 as we proceed. Zero on the decibel scale represents the sound intensity that can scarcely be heard by the average person.

Each increase of 1 decibel makes the sound audible enough to be detected by the ear. Noise levels of 110 to 120 decibels and above are common in the vicinity of operating jet aircraft engines. In fact, multiengine jets frequently exceed 130 db. But you may suffer physical injuries at these higher levels unless you are suitably protected. In contrast, noise levels of 84 db and below are considered relatively safe. Consequently, all personnel who routinely enter areas where 84 db is exceeded must have an audiogram performed at least once each 12 months in accordance with AFM 161-35 (hazardous noise exposure). Note, then, that research findings indicate that for prolonged exposures (day after day), 95 db is the maximum safe noise intensity level advisable.

Ear defenders, the proper selection of aircraft runup areas, and noise-suppression devices protect against these noise hazards, and the use of warning signs can prepare you to take the necessary precautions when you must be where noise hazards exist. So when you see "Warning, noise area, may cause hearing loss," use proper ear protection. The noise intensity of jet aircraft is greatest to the rear of the engines at an angle of 45° on either side. Therefore, do not work or stand in these high-intensity noise areas unless it is absolutely necessary. Look at figure 7-13 at this point. Remember, earplugs alone will not give you enough protection when you must be where levels of 130 to 140 db exist. Thus, if you must work in these areas, wear a headset in addition to using earplugs. Then, keep the period of your exposure as short as possible.

Three factors must be considered where determining critical noise intensities. These are:

- Intensity of noise (db).
- Duration of exposure.
- Duration of rest periods between exposures.

Sounds louder than the ear is accustomed to, especially high-pitched sound, such as whistles, tire a person's ear and make it less sensitive. Ordinarily, any loss of hearing is temporary, and after a suitable rest period, the individual will recover. However, if a person is repeatedly exposed to fatiguing noises, he may suffer permanent impairment of hearing. The point is, if you are the type of individual who frequently goes out onto the flight line without wearing some type of ear protection, this practice will catch up with you in later years. A person who has worked too long in areas with high db levels will show symptoms of sickness or injury. He may have pain, a feeling of fullness, and a ringing or burning of the ears; dizziness; impairment of mental concentration; and occasionally nausea, vomiting, or weakness of the knees. Emotional irritability is also often a sign of noise fatigue. Note, then, that whenever you or

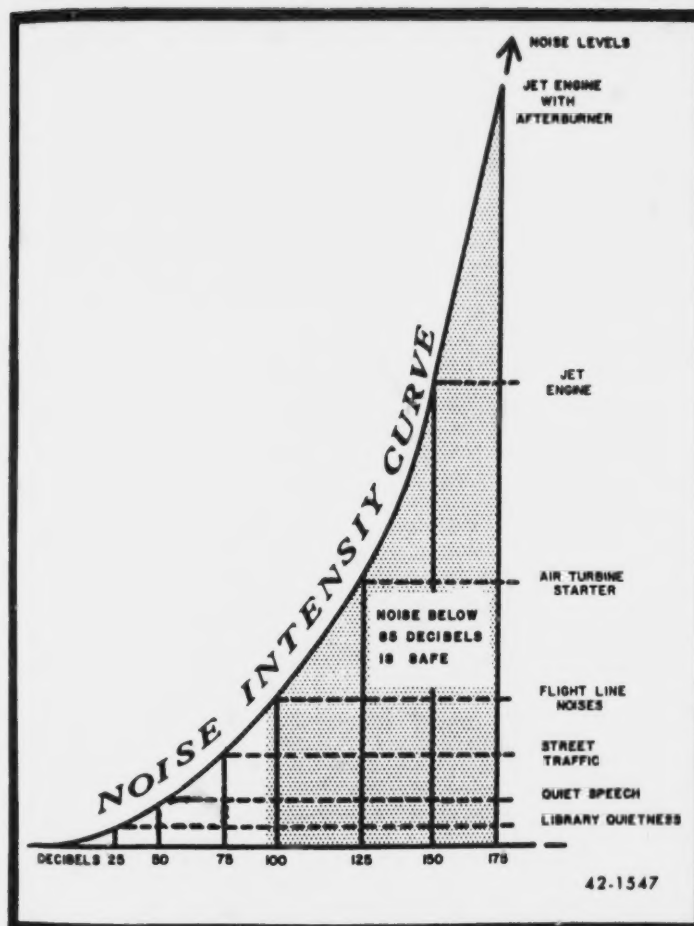


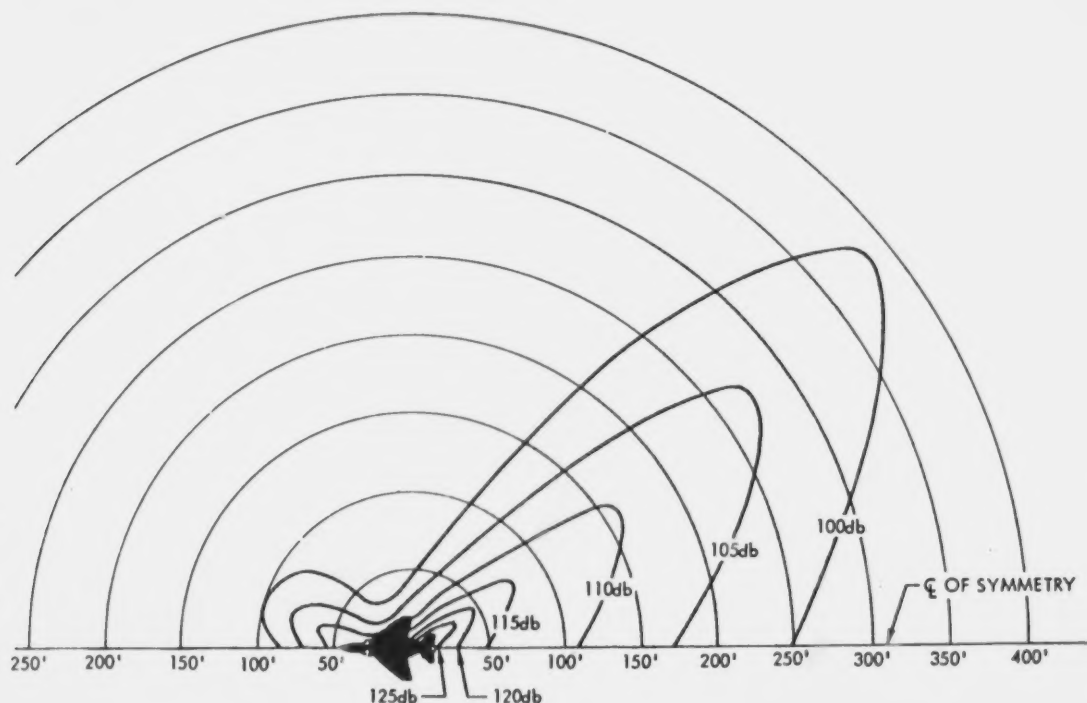
Figure 7-12. Noise intensity curve.

anyone notes any of these symptoms in personnel, take the affected person(s) from the noise area immediately. Then have a medical officer examine him before the affects wear off.

3. For prolonged noise exposure (day after day), what is considered the maximum noise intensity toleratable before temporary or permanent hearing loss occurs?

Exercises (097):

1. Where is noise intensity the greatest around operating jet aircraft?
2. What protective device should a mechanic wear, in addition to earplugs, when working in high-intensity noise areas?
4. Refer to figure 7-12 and indicate with a plus (+) each condition not considered harmful and with a minus (-) each condition considered harmful among the following.
 - ___ a. Operating jet engine.
 - ___ b. Street traffic.
 - ___ c. Flight-line noise.
 - ___ d. Noise below 84 db.
 - ___ e. Noise above 84 db.



NOISE LEVEL HAZARDS

42-1535

Figure 7-13. Noise level hazards.

098. Describe briefly the hazards and precautions to be observed when working on aircraft with power-actuated systems.

Power-Actuated Systems. Aircraft with power-operated (mostly hydraulic) devices, such as flight control surfaces and landing gear, present a potential danger. If you carelessly operate any of these, you can damage equipment or seriously injure someone. These systems are designed to operate quickly and against heavy airloads. They can be quite dangerous unless all precautions are observed. Most power-actuated systems have safety locks which must be installed during ground operations. As an example: Before going into a bomb bay to work, make sure that you deplete hydraulic pressure and install the safety locks. If someone accidentally tries to operate the system while you are working inside, the lack of hydraulic pressure and the safety locks will prevent the bomb doors from slamming shut. Don't get trapped by someone throwing levers or switches! Curiosity can be dangerous, and there is a little bit of it in everyone. When operating systems to check them

out, make sure that they are clear of personnel and equipment. Have someone stand by to make sure that everyone stays clear of the danger area. By all means, don't work on a system when hydraulic pressure is applied or the system is being operated. This has probably caused more deaths and injuries than any other single operation.

The flight control surfaces, landing gear doors, bomb bay doors and cargo loading doors—just to name a few—all have sharp edges. Therefore, when working on or near these edges, be especially cautious; serious injuries have occurred when persons simply arose too quickly from kneeling down under a landing gear door or walked into sharp edges of the flight control surfaces. Wear your cap and fatigue jacket when working around these areas. They will offer you some protection.

Exercises (098):

1. Describe briefly the hazard present on aircraft having power-actuated systems.

2. Cite the precaution to be observed when you are working on power-actuated systems.
3. When operating power-actuated systems, what must you do?
4. What common protective devices are used to prevent injuring yourself on sharp edges of aircraft?

099. Describe briefly the hazards of an overheated brake assembly and give precautions to take to prevent injury to personnel when an overheated brakes situation exists.

Overheated Brakes. As a pneudraulic mechanic, you may be called upon to work on an aircraft that has been subjected to excessive braking. The wheels may be heated to the point where there is danger of a blowout or fire. Excessive brake heating weakens the tire and wheel structure, increases tire pressure, and creates the possibility of fire in the magnesium wheel. When the brakes on an aircraft have been used excessively, the fire department should be notified immediately, and all unnecessary personnel should be advised to leave the immediate area. If a blowout screen is available, it should be placed around the overheated wheels. These blowout screens help to eliminate the possibility of damage or injury in the event of a blowout. If the tire is flat, explosive failure of the wheel or tire will not result. However, upon sudden cooling, an overheated wheel may fracture or fly apart, which could hurl bolts or fragments through the air with sufficient speed to injure personnel.

Required personnel should approach overheated wheels with extreme caution in the aircraft's nose or tail direction—never in line with the axle. The areas on both sides of the tire and wheel (in line with the axle), are those into which fragments would be hurled if the tire were to explode. This is why they are called "danger areas."

Heat transferred to the wheel will continue until the brake is cooled. Therefore, the danger of explosive failure may exist after the aircraft has

been parked if action is not taken to cool the overheated brake.

The recommended procedure for cooling overheated wheel, brake, and tire assemblies is to park the aircraft in an isolated location. Then allow the assembly to cool in ambient air for a period of 45 to 60 minutes. The use of cooling agents to accelerate cooling is not recommended unless operational necessity dictates their use. The application of the cooling agents exposes personnel to danger by requiring their presence near the overheated assembly. However, if it is necessary to accelerate cooling, direct a stream of water on the brake. The water should be applied in 10 to 15-second periodic bursts, not in a continuous discharge. Each application should be separated by a wait period of at least 30 to 60 seconds. A minimum of three to five applications is usually necessary. If water is not available, use any other nonflammable liquid available. (NOTE: The use of CO₂ for cooling is not recommended.)

Once the brake has been properly cooled, permit the wheel to cool in ambient air. A crosswind or forced air from a blower or fan will assist in cooling the wheel. The aircraft should not be moved for at least 15 minutes following cooling operations.

Exercises (099):

1. Describe briefly the hazards associated with an overheated brake assembly.
2. In which direction should you approach an aircraft which has overheated brakes?
3. List the precautions you should take to prevent injury to personnel when an aircraft reports that it has overheated brakes.
4. When it becomes necessary to apply a cooling agent to an overheated brake, what is the recommended cooling agent?

Answers for Exercises

CHAPTER 1

Reference:

- 001 - 1. a. Electrical.
b. Environmental.
c. Egress.
d. Aircraft fuel.
e. Pneudraulics.
f. Aerospace Ground Equipment.
2. a. 3.
b. 1.
c. 6.
d. 4.
- 002 - 1. It is a condensed form of all the duties and responsibilities performed by an individual in a given AFS.
2. No. The specialty description does not indicate that propellers would be removed and replaced by a pneudraulic mechanic.
3. Yes.
4. It describes the duties, responsibilities, and special qualifications needed to perform in a given AFS.
5. AFM 39-1, *Airman Classification Manual*.
- 003 - 1. a. 2.
b. 4.
c. 1, 3.
d. 5.
- 004 - 1. An individual who qualifies for a specialty by virtue of prior civilian or military occupational experience and schooling.
2. As a bypass specialist, by taking the Apprentice Knowledge Test; by attending a formal technical school; or by going to a direct duty assignment.
3. c, d, b.
4. 5 skill level.
5. You must be an E-5 or above holding a 5 skill level. You must also complete the 7-level CDC and a course in management training. After this you must perform for 1 year in a 7-level capacity and then be recommended by your supervisor.
6. He must be at least an E-7 and pass the supervisors' examination, then be recommended by his supervisor.
- 005 - 1. a. Specialty knowledge test.
b. Promotion Fitness Examination.
c. Time in service.
d. Time in grade.
e. Decorations.
f. Airman Performance Report.
2. It measures your knowledge concerning your Air Force Specialty; in this case, Pneudraulic Mechanic.
3. The Promotion Fitness Examination (PFE).
4. By multiplying the total years of active military service by two, with less than 6 months counting as one point and 6 months or more counting as two points.
5. 6 points.
6. Airman Performance Reports.
- 006 - 1. It would be costly and boring and valuable time needed for other duties would be wasted.
2. To determine how much the trainee can already do.
3. By observing the trainee's methods or work habits, the trainer can determine whether or not a trainee requires additional training.
- 007 - 1. It is a planned training program designed to qualify airmen, through self-study and supervised instruction, to perform in a given Air Force Specialty.
2. Self-study through Career Development Courses and job proficiency.
3. Job proficiency.
4. AFM 50-23, *On-the-Job Training*.
- 008 - 1. b.
2. a.
3. d.
4. b.
5. a.
6. b.
7. c.
8. d.
9. c.
- 009 - 1. Demonstration.
2. Discussion.
3. Demonstration.
4. Performance.
5. Preparing the trainee to receive job instruction.
6. Presenting the operation to the trainee.
7. Preparing the training situation.
8. Followup.
9. Trying out performance.
- 010 - 1. AF Form 623a.
2. AF Form 623, Section IV, ECI/CDC Participation, Etc.
3. AF Form 623, Section I, Identification Data.
4. AF Form 623, Section II, Orientation and Certification.
5. AF Form 623, Section III, Reading Achievement Test.
6. AF Form 623, Section I, Identification Data.
7. AF Form 623, Section IV, ECI/CDC Participation, Etc, column B
- 011 - 1. On the inside cover of the STS, in the Immediate Supervisor's Name and Initials block.

2. The supervisor will circle in pencil the "proficiency level."
 3. The supervisor will enter in pencil the data the training begins.
 4. Any additional training not on the STS/JP will be entered on AF Form 797, Job Proficiency Guide Continuation Sheet.
- 012 - 1. To aid in quality control of formal and Career Development Courses.
2. a. Field evaluation visits.
b. The CDC Trainee Questionnaire.
c. The direct correspondence questionnaire.
d. The Training Quality Report.
 3. It lets the immediate supervisor inform the training activities directly when a graduate does not meet the proficiency level specified in the STS.
 2. The supervisor will circle in pencil the "proficiency level."
 3. The supervisor will enter in pencil the data the training begins.
 4. Any additional training not on the STS/JPG will be entered on a AF Form 797, Job Proficiency Guide Continuation Sheet.
- 012 - 1. To aid in quality control of formal and Career Development Courses.
- 012 - 2. a. Field evaluation visits.
b. The CDC Trainee Questionnaire.
c. The direct correspondence questionnaire.
d. The Training Quality Report.
3. It lets the immediate supervisor inform the training activities directly when a graduate does not meet the proficiency level specified in the STS.

CHAPTER 2

- 013 - 1. Unclassified.
2. Unclassified, but of possible intelligence value.
3. Unclassified.
4. Unclassified.
5. Unclassified, but of possible intelligence value.
- 014 - 1. Official Use Only.
2. Secret.
3. Top Secret.
4. Confidential.
- 015 - 1. T.
2. T.
3. T.
4. F. This should be everyone's responsibility.
5. T.
6. F. The unit security officer determines this.
7. T.
- 016 - 1. F. Documents are not marked on both sides.
2. T.
3. T.
4. F. The documents should not be left alone even for a moment.
- 017 - 1. d.
2. a.
3. b.
4. e.
5. d.
6. a.
7. e.
- 018 - 1. a. Illegal wire tapping.
b. The use of radio relay systems.
c. Uninvited listeners.
- d. Malfunctions.
e. The sensitivity of the telephone transmitter.
2. a. 4.
b. 5.
c. 2.
d. 3.
e. 6.
f. 8.
- 019 - 1. Activities conducted in secrecy.
2. Any act to destroy material, equipment, or buildings.
3. That possible hostile event which could affect the ready general war capability has been detected.
4. a. Modern technology's weapons.
b. Cost of maintaining a security force.
5. Helping hand and covered wagon.
6. A security force which can be augmented with additional personnel as necessary.
- 020 - 1. Exchange badge procedure.
2. Single badge procedure.
3. Personal recognition.
4. Telephone or radio verification.
- 021 - 1. To grant unescorted entry into a restricted area.
2. To indicate restricted areas on a base.
3. The E indicates an escort official for that particular area.
4. The frequency of his being needed in the area and his security clearance.
5. Supervisory personnel who can make valid determination that there are official needs for a person to enter a restricted area.
6. To determine whether or not a person should be permitted to enter a restricted area.
7. Yes.
- 022 - 1. Operational Security is the prevention from disclosure of sensitive information to the enemy about a military operation.
2. Objectives of OPSEC are to:
a. Identify operations requiring protection.
b. Develop procedures and techniques for security.
c. Assess OPSEC status at all levels.
Your answers should be close to these.
- 023 - 1. A need for operational security was determined when the enemy instituted countermeasures, prior to our operations, indicating that they had been warned.
2. The assembly of personnel and materiel into a certain area.
3. During the 1960's, when we were involved in combat operations in Southeast Asia.
- 024 - 1. Information, COMSEC, and OPSEC Security Programs were all violated. The airmen were talking about information, within the hearing of an unauthorized person, that could be of intelligence value in determining that a military operation was planned and where it might be.
2. Information, COMSEC, and OPSEC Security Programs were all violated. The sergeant was discussing classified information concerning a new bomb and an operation. Although his friend had a Secret clearance, he did not have a need-to-know. Also there were other unauthorized persons who could hear the discussion.
- 025 - 1. The following applies:
a. Situation "A" would disclose information about an operation, as it would "flag" associated actions.

- b. Situation "b" would not reveal any information about an operation.
 - c. Situation "c" would indicate a change in pattern or that preparations in obtaining supplies for an operation exist.
 - d. Situation "d" would indicate that preparations for an increased flying operation exist.
 - 2. The operation objectives, time, location, and the forces involved are examples of information needing protection.
- 026 - 1. This information is valuable to the enemy and should not be revealed to unauthorized persons or persons who do not have a need to know.
2. Information about the type of aircraft, location, and time of deployment must be considered of intelligence value. This information should not be revealed to unauthorized persons.

CHAPTER 3

- 027 - 1. Departmental and field.
2. Air Force regulation (AFR).
3. Air Force pamphlet (AFR).
4. Operating instructions.
5. Supplements are used to implement, amplify, interpret, or clarify a higher level publication.
- 028 - 1. The first number shows the basic subject.
2. The second number indicates exactly what area is covered.
3. An Air Force publication.
- 029 - 1. AFR 0-2 lists Air Force regulations, manuals, pamphlets, recurring publications, and visual aids.
2. You would look in the alphabetical listing of AFR 0-2.
3. You would look in the numerical listing of AFR 0-2.
4. AFR 0-9.
- 030 - 1. Master and functional publications libraries.
2. Functional.
3. AFR 5-31.
4. Check the publication date of the manual against the date in the index.
5. This indicates that a publication is on order but that a current copy is not on hand.
6. 6 May.
- 031 - 1. The zero (0) indicates an index technical order.
2. Fighter type aircraft.
3. -6 (Inspection Requirements).
4. This designates the aircraft model and series.
5. Parts catalog.
6. To show modification to the equipment.
- 032 - 1. 29 Jul 76.
2. Chg 2, 25 May 72, with a security classification of Unclassified.
3. OO (Ogden, Utah).
4. 9H1-3.
5. I-5.
6. 9H1-3-2-3.
- 033 - 1. This manual lists all the TOs that apply to a specific aircraft.
2. -I flight manual.
3. Special tools, disassembly, cleaning, inspection, repair, replacement, and reassembly instructions for overhaul of components or equipment.
4. Scheduled inspection and maintenance requirements.
- 034 - 1. 9H8-568-2.
2. The list of Leading Particulars provides general information pertaining to such things as type of hydraulic fluid, pressure adjustments, and operating temperatures.
3. Usually in the front of the overhaul instructions TO.
4. They tell you that the shuttle is actually a part of the shuttle and sleeve assembly.
5. 2.
6. F.
7. PID - P1 indicates parts very difficult, impracticable, or uneconomical to manufacture. The letter "D" indicates depot maintenance.
- 035 - 1. Circled red X.
2. a. Immediate action.
- b. Urgent action.
- c. Routine action.
3. Upon receipt of the immediate action TCTO.
4. Routine action.
5. An interim TCTO is a temporary TCTO that takes the place of an immediate or urgent action TCTO until they are printed.
- 036 - 1. a.
2. a.
3. b.
4. a.
5. c.
6. a.
- 037 - 1. AFTO Form 32.
2. In the same numerical order in which they are listed in the numerical index and requirements tables.
3. It is the second book of the 4 series TOs.
4. a. Operational.
- b. Aircraft.
- c. Transient aircraft.
5. This would contain only those TOs required to accomplish the operation and maintenance of the activity they serve.
- 038 - 1. a. Revisions.
- b. Changes.
- c. Supplements.
- d. Rescissions.
2. When changed pages total 80 percent or more of the basic TO.
3. Miniature pointing hands.
4. You would look on the list of effective pages, which is on the back of the title page.
5. They are normally issued when time and circumstances prevent issuing a standard change.
6. Safety and operational supplements are filled in numerical sequence by date, in front of the basic TO.
- 039 - 1. Because, the word "Caution" means that equipment may be damaged if the procedures that follow in the TO are not observed.
2. It is used to add emphasis to essential material.
3. The word "Warning" means that a violation of the procedures that follow could result in injury or death.
4. Yes. If external power is applied (step 15) before the circuit breaker is pulled (step 16), it could cause damage to equipment.

CHAPTER 4

- 040 - 1. Air Force Logistics Command (AFLC).
2. They are geographically located areas designed to support specific functions of materiel support.

3. a. Management of assigned national stock classes.
b. Management of assigned systems.
 4. a. Equipment Management Office (EMO).
b. Supply Management Office (SMO).
- 041 - 1. a. 2.
b. 1.
c. 1.
d. 3.
2. a. F.
b. T.
c. F.
d. F.
e. T.
- 042 - 1. T.
2. F. Critical items are those that are in short supply and the demand for them is excessive.
3. T.
4. F. Use only the proper priority.
5. T.
6. F. A repair cycle asset is an item with the ERRC designator of XD or XF.
7. T.
8. T.
9. T.
- 043 - 1. 13.
2. 9.
3. 3a.
4. 22.
5. 24.
6. 15.
7. 29.
8. 14.
9. 26.
- 044 - 1. a. Blocks 4, 5, 6 Delivery Destination.
b. Blocks 34 and 35, Shop.
c. Blocks 25 through 29, Quantity.
d. Block 30, Activity.
2. a. Block J, Demand Code.
b. Block L, Priority.
c. Block A, Delivery Destination Code.
d. Block Q, Time.
- 045 - 1. T.
2. T.
3. F. The person in charge of the maintenance activity has sole responsibility for bench stock.
4. F. He merely helps himself to what is needed.
5. T.
6. F. Bench stock support makes the labels.
7. T.
8. T.
9. F. Personnel from bench stock support conducts the monthly physical inventory.
10. T.
- 046 - 1. a. Deleted.
b. 01, general support.
c. 235.
d. Lb (pound).
e. 4.
2. A controlled item.
3. a. 2 months.
b. 30 months.
c. 48 months.
d. 72 months.
- 047 - 1. d.
2. a.
3. b.
4. f.
5. a.
6. e.
7. c.
8. b.
9. a.
10. d.
- 048 - 1. F. Any individual can be charged with responsibility of Air Force property be it, command, supervisory, or custodial.
2. T.
3. F. Although this is partially true, because you are using it, you are charged with custodial responsibility also.
4. T.
5. T.
6. F. Even a commander can be charged with pecuniary liability.
7. F. It would be almost impossible for the commander to know all the details required of record-keeping of equipment.
8. T.
9. T.
10. F. The supervisor is responsible for property in transit, storage or undergoing modification or repair.
11. T.
12. T.
13. T.
14. T.
- 049 - 1. Transfer the account to the person who becomes acting supervisor.
2. Turned into Supply. This will relieve the branch of supervisory custodial and command responsibility for the chains.
- 050 - 1. F. Only the statement of charges can be used for payroll deduction.
2. T.
3. T.
4. T.
5. F. When pecuniary liability is admitted, property responsibility can be relieved by a cash collection voucher or a statement of charges. The report of survey is used when pecuniary liability is not admitted.

CHAPTER 5

- 051 - 1. a. Collection process.
b. Storage.
c. Retrieval.
2. You should have given any three of the following:
a. Analysis of high-rate-of-failure systems and components.
b. Validation of inspection and time change intervals.
c. Determination of status of equipment modifications.
d. Validation of manpower and of spare parts.
e. Identification of systems which consume maintenance man-hours at an unusually high rate.
3. You should have given any three of these four:
a. Production credit information.
b. Equipment maintenance schedules.
c. Direct labor expenditures.
d. Materiel failures.
4. BLIS gives maintenance managers a means of retrieving selected MDC information which is stored in the computer.

- 052 - 1. a. On-equipment.
b. Off-equipment.
c. Productive indirect.
2. Time compliance technical order (TCTO).
3. Coded information is used to simplify data recording, to standardize documentation, and to reduce writing time for the maintenance personnel. It also simplifies data retrieval.

053 - 1. Block 3.

2. Maintenance control.
3. When it is used as a dispatch form.
4. The time that the work is scheduled to start.
5. The estimated clock hours.
6. The NIIN will be used when an item does not have a part number.
7. Column C.
8. Work order number.
9. The mission, design, and series (MDS).
10.

MAINTENANCE DATA COLLECTION RECORD														FORM NO. 21-80027			
1. JOB CONTROL NO.		2. WORKCENTER		3. I.D. NO./SERIAL NO.		4. MDS		5. EQ/CL		6. TIME		7. PRI		8. SORTIE NO.		9. LOCATION	
0270012		Q3340		QA3407								2				B7	
10. ENL. TIME		11. ENHSE I.D.		12. INST. ENL. TIME		13. INST. ENL. I.D.		14.		15.		16.		17. TIME SPC REQ		18. JON STD.	
														0830		3.0	
19. FSC		20. PART NUMBER		21. SER. NO./OPER. TIME		22. TAG NO.		23. INST. ITEM PART NO.		24. SERIAL NUMBER		25. OPER. TIME					
ACT. LINE	A	B	C	D	E	F	G	H	I	J	K	L	M	N			
	TYPE MAINT	COMP JOB	WORK UNIT CODE	ACTION TAKEN	WHEN DISC	HOW MAL	UNITS	START HOUR	STOP HOUR	CREW SIZE	CAT LAB	CMD ACT ID	SCM CODE	EMPLOYEE NUMBER			
1	B		13221	R	F	381	1	0830	27	1030	1	1			78436		
2																	
3																	
4																	
5																	
26. DISCREPANCY																	
Nose Landing Gear Actuator Leaking																	
27. CORRECTIVE ACTION																	
Removed and Replaced Nose Landing Gear Actuator I/A/W IC-130B-2-12 Par 4-32 Fig 4-8																	
																28. RECORDS ACTION	

AFTO FORM 349 MAY 78

PREVIOUS EDITION IS OBSOLETE.

Figure 1. AFTO Form 349 (answer for objective 053, exercise 10).

- 054 - 1. Indirect labor.
2. In the -06 work unit code manuals (see foldout 1, part F).
3. The start and stop time will be entered during normal duty hours.
- 055 - 1. They should be legible in order to reduce errors caused by somebody misinterpreting your writing.
2. First name initial, complete last name, and rank or grade.
3. 15/10/4.
4. Will the reader understand?
- 056 - 1. They represent, in the opinion of the individual making the entry, that certain conditions exist requiring attention that may affect mechanical

condition, fitness for flight or operation, servicing or inspection of that equipment.

2. Red X, circled red X, red dash, red diagonal, and black last name initial.
3. Never. Once entered, even in error, it must be cleared properly with an adequate explanation in the Corrective action block and signed off.
4. The red X.
5. The circled red X.
6. An unknown condition.
7. The red diagonal.
8. A black last name initial over a red symbol indicates that the condition has been corrected.
9. To make important notations instantly apparent.

057 - 1 and 2.

AFTO FORM 781A
MAY 78

PREVIOUS EDITION
IS OBSOLETE

CHAPTER 6

- 063 - 1. The President of the United States.
 2. These are, in sequence, as follows:
 a. The President.
 b. The Secretary of defense.
 c. The Secretary of the Air Force.
 d. The Chief of Staff.
 e. The major command.
 f. The numbered Air Force.
 g. The wing headquarters.
 h. The Deputy Commander for Maintenance.
 i. The squadron commander.
 j. The maintenance officer.
 k. The aerospace systems branch.
 l. The pneudraulics shop.
 3. a. 1.
 b. 2.
 c. 3.
 d. 1.
 e. 2.
- 064 - 1. a. 3.
 b. 1.
 c. 3.
 d. 1.
 e. 2.
 2. a. Periodic.
 b. Phased.
 c. Isochronal.
 3. Periodic.
 4. Periodic.
 5. The primary objective of the phased inspection is to reduce the length of time that an aircraft is out of commission for any given scheduled inspection.
 6. Thruflight inspection.
- 065 - 1. He is always the most qualified maintenance officer in the organization.
 2. a. Maintenance control.
 b. Quality control.
 c. Production analysis.
 d. Administration.
 e. Training management.
 f. Programs and mobility.
 3. To direct and guide subordinate activities in the accomplishment of the assigned mission.
 4. You should have placed an X by b, f, g, and h.
- 066 - 1. Maintenance control is responsible for directing the maintenance production activity, authorizing the expenditure of resources, and controlling the actions required to support the mission.
 2. a. Job control.
 b. Plans and scheduling and documentation.
 c. Materiel control.
 3. Maintenance control.
 4. Documentation.
 5. Materiel control.
 6. a. Maintenance supply liaison (MSL).
 b. Production control.
- 067 - 1. a. Performing inspections of maintenance actions.
 b. Performing personnel evaluations.
 c. Monitoring the currency and applicability of technical data.
 d. Providing assistance to maintenance supervisors.
 e. Maintaining the control technical order library.
 2. To assure high-quality maintenance production and equipment reliability.
3. An objective sampling of both the quality of equipment maintenance and the qualification of maintenance personnel.
 4. Technically qualified; temperamentally suited; communicative skills.
- 068 - 1. Management administration is the management center of the maintenance complex. It maintains files, prepares and submits maintenance reports and controls maintenance administrative procedures. It also is responsible for sorting and grouping all AFTO Forms 349s.
 2. T
 2. To provide information to be used to improve the maintenance operation.
 3. The reports enable maintenance managers to project existing capabilities into plans and schedules and to institute controls to prevent variations.
 4. The problem is referred to the appropriate staff activities or production supervisors.
- 069 - 1. To insure that a continuous, well-organized training program is established and managed throughout the maintenance complex.
 2. Only when an individual shows qualification deficiency or when a change in assignment or equipment occurs.
 3. Functions, relationship (and) procedures.
 4. It controls and schedules initial evaluations to identify each individual's qualifications.
- 069 - 5. It is the program that provides the basic Air Force Specialty training to meet job knowledge and skill-level requirements. Through the dual-channel concept, it divides career development into (1) acquiring job knowledge by self-study of career development courses and (2) acquiring job proficiency by performing under the supervision of a skilled technician.
- 069 - 6. This is a continuous process from an individual's first assignment qualification evaluation, based on the STS or JPG—using the procedures in AFM 50-23. Following completion of the individual's supervisor's initial qualification evaluation, a reevaluation is needed only when the individual has a qualification deficiency is needed only when the individual has a qualification deficiency identified or when an equipment change or assignment change takes place.
- 070 - 1. a. Mobility planning.
 b. Financial management.
 c. Maintenance manning.
 d. Facility management.
 2. Financial management.
 3. This section of programs and mobility will monitor the maintenance manning authorizations and personnel assignments to these positions.
- 071 - 1. a. AMS.
 b. OMS.
 c. FMS.
 d. MMS.
 2. a. Propul.
 b. AGE.
 c. FAB.
 d. ASB.
- 072 - 1. MIMICS utilizes computer technology to provide summarized or detailed reports to aid maintenance managers.
 2. The documentation section of maintenance control can use this information to update inspection and/or time change records.

- 3 By extending the capability of the training personnel by absorbing the administrative burden of maintaining files. It also provides them a pool of data from which training needs can be determined and validated.
 4. Job control.
- 073 - 1. The mission of the aerospace systems branch is to provide specialist support to other maintenance activities.
2. a. Repair/reclamation.
 - b. Fuel systems.
 - c. Electrical systems.
 - d. Pneudraulics.
 - e. Environmental.
 - f. Wheel and tire.
 - g. Egress systems.
 3. The inspection section.
 4. The repair, overhaul, and testing of system components.
- 074 - 1. It can show how a particular shop fits into the maintenance organization.
2. He can use it to help him in orienting new personnel.
 3. A functional chart is much like the organizational chart, except that the duties and responsibilities of each position are listed on the chart.
 4. It serves as a quick reference of what responsibilities a specific position carries with it.
- 075 - 1. Job control.
2. Call job control and arrange to have the tire removed. Then inform job control that after the tire is removed to schedule the pneudraulic specialist.
 3. In order to result in a well-balanced smoothly operating organization.
- 076 - 1. As task requirements arise, the supervisor must plan and schedule work assignments and set priorities.
2. Manpower and equipment.
 3. Because by proper scheduling, the shop supervisor can be assured that the equipment and personnel to accomplish the job will be there when they are needed.
 4. To insure that the equipment needing the repair first is placed over the repairs of a lesser job.
 5. Your answer should parallel this: No. In fact, this shows good planning on his part, because if any emergencies were to arise, he would have a replacement already trained.
- 077 - 1. Because, even if an individual has a 7 skill level, he may be less knowledgeable about an aircraft malfunction than is someone who has had prior experience on that particular aircraft.
2. The 3 and 7 skill level should be assigned to remove the equipment for bench check. The trained 5 skill level should be assigned to the troubleshooting task.
 3. The priority of the job.
- 078 - 1. The supervisor has lost the meaning of having two people check the completed work. Two people are better than one.
2. There are two good reasons for a supervisor's checking the quality of work. First, it insures that the equipment is in safe operating condition and, second, it can be an excellent learning device.
 3. The supervisor should praise the job that was done, but he should also point out the safety wire. He should then have the man resafety it correctly.
4. By waiting the job is completed, instead of performing in-progress inspections, harsh feelings and loss of ambition of a subordinate could result, especially if the job needs to be redone.
- 079 - 1. It gives the supervisor an idea where the workers are being employed.
2. He could have used the MDC file in the shop or he could have gone to the documentations section.
 3. Two.
- 080 - 1. The level of performance standards should be set at a level attainable by the average worker.
2. If the situation is not corrected as soon as possible, it may appear to be the standard, and other personnel may do the same.
 3. July of next year.
 4. To rate the personnel fairly, as the supervisor you must compare them with other personnel of the same rank, skill level, and job knowledge.
- 081 - 1. a. Unit mission.
- b. Number of personnel.
 2. From the unit detail listing (UDL).
 3. He should get the facts and discuss them with the commander. If the commander agrees with the supervision, then justification for additional people can be submitted.
 4. This is determined by major commands and base equipment management offices.
 5. a. Number of aircraft maintained.
 - b. Size of the workload.
 - d. Number of personnel.
 - e. Climatic conditions.
- 082 - 1. To the boss (supervisor).
2. Ask for outside help.
 3. To find out if the situation has been corrected.
 4. He should counsel the individual.
 5. The supervisor should point out what is expected of the individual at all times.
 6. The supervisor can refer the individual to the commander.
 7. The commander can give a verbal or written reprimand.
 8. The commander could use the Article 15, or even court martial.
- 083 - 1. It sometimes suggests a solution.
2. To get the person's story straight, and it may put the complainer in a better frame of mind.
 3. Refer the individual to someone else better qualified in the subject.
 4. a. Get the facts.
 - b. Weigh and decide.
 - c. Take action.
 - d. Check results.
 5. Because, indirectly, an individual's personal problems could affect his work.
- 084 - 1. a. By discussing your ideas, using the chain of command.
- b. The complaint program.
 - c. The suggestion program.
 2. Suggestion program.
 3. You will get an explanation as to why it can't be used.
 4. The complaints NCO or officer.

CHAPTER 7

- 085 - 1. Natural phenomena.
2. Unsafe acts and conditions.

3. Inattentiveness, excitability, impatience, and stubbornness.
 4. Adequate safety education.
 5. To determine whether or not additional or special training is necessary.
- 086 -
1. The supervisor.
 2. By planning the arrangement from the start.
 3. Use suitable containers until they can be disposed of properly.
 4. They can cause slips and falls.
 5. a. Arrangement of equipment.
b. Arrangement of lighting.
c. Storage of tools.
d. Disposal of waste.
 6. Storage, roads and grounds, and lighting.
 7. Storing materials under a stairway could cause someone to trip; this also creates a potential fire hazard.
 8. Weeds and grass, if not controlled, could greatly increase the chance of fire.
 9. To prevent personnel from bumping into or tripping over permanent obstructions.
- 087 -
1. a. Class A.
b. Class B.
c. Class C.
d. Class D.
 2. Heat, fuel, and oxygen.
 3. Your answer should agree with this:
a. Class A—wood, paper, rags.
b. Class B—flammable liquids.
c. Class C—electrical.
d. Class D—combustible metals.
- 088 -
1. a. 2.
b. 1.
c. 2, 3.
d. 1, 2.
e. 1.
f. 1.
g. 2, 3.
h. 4.
 2. a. T.
b. F. Water pump extinguishers cool.
c. T.
d. T and F. It is used to cool and to smother.
 3. a. Don't haphazardly direct the CO₂ over a flame, it could cause a flashback. Besides, this CO₂ is extremely cold, and you could receive frost bite.
b. Don't use on electrical fires.
c. Use in well-ventilated areas because it is poisonous.
d. Water will make a petroleum fire spread and should never be used on electrical fires.
- 089 -
1. Wear protective equipment and have proper ventilation.
 2. Nontoxic; nonvolatile; nonflammable.
 3. From breathing and by direct skin contact.
 4. Bacterial infection.
 5. Store them in approved containers and excessive heat or flames.
 6. It could cause the container to rupture due to excessive thermal expansion of the contents.
- 090 -
1. Poor judgment in the use of equipment.
- 090 -
2. a. Short circuits.
b. Overloading.
c. Accidental grounding.
d. Poor electrical contacts.
e. Misuse of equipment.
 3. Be sure that the power is turned off.
 4. You should remove all metallic objects.
5. Because wood can absorb moisture.
 6. You should only pull the switch if you know what will happen.
- 091 -
1. 4 psi.
 2. If the container were to crack, it could explode like a bomb.
 3. Nitrogen is not flammable and is less corrosive.
 4. Oil-pumped nitrogen.
 5. It could cause oxygen starvation.
- 092 -
1. Remove any jewelry or loose clothing. Next, check the condition of the route to be taken. Then check object to be lifted for slippery substances, protruding nails, etc.
 2. Assume a squatting position, with your back straight, and allow your legs to exert the lifting force.
- 092 -
3. Match as nearly as possible the height of personnel who will be carrying the object, check the route to be taken for obstacles, and have an emergency signal.
- 093 -
1. a. Alpha.
b. Beta.
c. Gamma.
 2. Alpha.
 3. Beta.
 4. Gamma.
 5. It is measured in roentgens per hour.
 6. When taken internally.
 7. A dosimeter.
 8. By accidents involving the handling of radioactive material or the crashing of aircraft.
 9. It is a reddish purple symbol on a yellow background.
- 094 -
1. a. Radio transmitters.
Radar.
c. Electronic countermeasure devices.
 2. Burns beneath the skin, cataracts over the eyes, and damage to internal organs.
 3. Don't stand in the beam of radio-frequency radiation.
 4. The radiation absorption screen.
- 095 -
1. The explosive charges on the canopy and ejection seats.
 2. By firing the shielded mild detonation cord (SMDC).
 3. Flying debris and burns from the rocket blast.
 4. Make sure that the safety pins are installed.
 5. A disease of persons who just can't prevent themselves from turning every lever or switch they see.
 6. It can jam a control or strike the pilot or control panel, causing personnel injury or equipment damage.
- 096 -
1. a. Intake.
b. Engine exhausts.
c. Engine turbine plane.
d. Cartridge starters.
e. Noise hazards.
 2. The turbine could disintegrate and throw pieces off, which could strike nearby personnel.
 3. By a painted red stripe on the aircraft.
 4. The high velocity of the air and its temperature.
 5. Check the applicable aircraft technical order.
 6. The suction effect.
 7. 25 feet.

8. This describes any foreign object that doesn't belong where it is and which could or has possibly caused damage or injury.
9. Account for all tools, hardware, and components.
10. a. Propeller.
b. Prop wash.

- 097 - 1. 45° on either side of the aircraft.
2. A headset.
3. 95 decibels.
4. a. -
b. +
c. -
d. +
e. -

- 098 - 1. These systems are designed to operate fast and against heavy loads. If all precautions are not followed, these systems can kill or crush you. Deplete hydraulic pressure and install safety locks.
2.
3. Make sure that the area is clear of personnel and equipment.
4. Fatigue jackets and caps.

- 099 - 1. It could cause fire or blowout of the tire.
2. From the nose or the tail direction.
099 - 3. a. The fire department should be notified immediately.
b. All unnecessary personnel should be advised to leave the area.
c. If a blowout screen is available, place it around the aircraft.
4. Water.

A**B****C**

TO 1C-130A-06

TECHNICAL MANUAL**AIRCRAFT MAINTENANCE****WORK UNIT CODE MANUAL****USAF SERIES****C-130****AIRCRAFT****FOR TRAINING
PURPOSES ONLY**

THIS PUBLICATION SUPERSEDES TO 1C-130A-06
DATED 1 JULY 1974.

THE EFFECTIVE DATE OF THIS PUBLICATION IS
1 OCTOBER 1975. CODES LISTED HEREIN SHALL
NOT BE USED PRIOR TO THAT DATE.

PUBLISHED UNDER AUTHORITY OF
THE SECRETARY OF THE AIR FORCE

31 AUG 1976

**CODE TYPE MAINTENANCE CODES
DESCRIPTION**

TYPE MAINTENANCE CODES FOR AIR-
CRAFT, DRONES, INSTALLED ENGINES
AND RELATED MOBILE TRAINING SETS
(MTS) AND RESIDENT TRAINING EQUIP-
MENT (RTE). ENGINE SHOP CODES ARE
INCLUDED FOLLOWING THIS LIST OF
CODES.

A SERVICE -

INCLUDES ALL UNITS OF WORK ASSOCI-
ATED WITH SERVICING, CLEANING AND
MOVEMENT OF EQUIPMENT.

B UNSCHEDULED MAINTENANCE -

INCLUDES ALL UNITS OF WORK
ACCOMPLISHED BETWEEN SCHEDULED
INSPECTIONS EXCEPT AS PROVIDED IN
PRECEDING CODE A, AND EXCLUDING
ACCOMPLISHMENTS OF TCTO'S. THIS
CODE INCLUDES REPAIR AND/OR
CALIBRATION OF ITEMS OR EQUIPMENT
BETWEEN SCHEDULED CALIBRATION
INTERVALS.

**C BASIC POSTFLIGHT OR
THRUFLIGHT INSPECTION -**

INCLUDES ALL UNITS OF WORK
ACCOMPLISHED DURING ALL PHASES OF
THE BASIC POSTFLIGHT OR THRU-
FLIGHT INSPECTION.

D PREFLIGHT INSPECTION -

INCLUDES ALL UNITS OF WORK
ACCOMPLISHED DURING ALL PHASES OF

**ACTION TAKEN CODES
CODE DESCRIPTION
(CONTINUED)**

N ASSEMBLE -

ASSEMBLY ACTION WHEN THE COMPLETE
MAINTENANCE JOB IS BROKEN INTO
PARTS AND REPORTED AS SUCH. DO NOT
USE FOR ON-EQUIPMENT WORK.

P REMOVED -

ITEM IS REMOVED AND ONLY THE
REMOVAL IS TO BE ACCOUNTED FOR.
IN THIS INSTANCE DELAYED OR
ADDITIONAL ACTIONS WILL BE
ACCOUNTED FOR SEPARATELY. (ALSO
SEE CODES Q,R,S,T AND U). DO NOT
USE FOR OFF-EQUIPMENT WORK.

Q INSTALLED -

ITEM IS INSTALLED AND ONLY THE
INSTALLATION ACTION IS TO
BE ACCOUNTED FOR. (ALSO SEE CODES
P,R,S,T AND U). DO NOT USE FOR
OFF-EQUIPMENT WORK.

R REMOVE AND REPLACE -

ITEM IS REMOVED AND ANOTHER LIKE
ITEM IS INSTALLED (ALSO SEE CODES
T AND U). DO NOT USE FOR OFF-
EQUIPMENT WORK.

S REMOVE AND REINSTALL -

ITEM IS REMOVED AND THE SAME ITEM
REINSTALLED (ALSO SEE CODES T AND

III-001

V-007

D

E

F

WHEN DISCOVERED CODES		HOW MALFUNCTIONED CODES		WORK	UNIQUE DATA CODES FOR MCS
CODE	DESCRIPTION	CODE	DESCRIPTION	UNIT	
			ALPHABETICAL LISTING	CODE	DESCRIPTION
			(CONTINUED)		
A	BEFORE FLIGHT-ABORT-AIR CREW	481	KEYWAY OR SPLINE DAMAGED OR WORN	AL700	ALERT DUTY -
B	BEFORE FLIGHT-NO ABORT-AIR CREW	410	LACK OF, OR IMPROPER LUBRICATION		
C	IN-FLIGHT ABORT	381	LEAKING-INTERNAL OR EXTERNAL		ALL MANHOURS EXPENDED WHILE
D	IN-FLIGHT NO ABORT	884	LEAD BROKEN		WAITING FOR ALERT AEROSPACE
E	AFTER FLIGHT-AIR CREW	383	LOCK ON MALFUNCTION		VEHICLES TO TAKEOFF OR LAND,
F	BETWEEN FLIGHTS-GROUND CREW	730	LOOSE-		SUCH AS STRATEGIC, DEFENSE,
H	BASIC POSTFLIGHT OR THRU-FLIGHT	105	LOOSE OR DAMAGED BOLTS, NUTS,		TACTICAL, STANDING BY FOR CRASH
	INSPECTION (WHICHEVER IS		SCREWS, RIVETS, FASTENERS, CLAMPS		ALERT, OR FOR ALERT MISSILES
	APPLICABLE)		OR OTHER COMMON HARDWARE		WHEN NO WORK IS BEING ACCOM-
J	PREFLIGHT INSPECTION	988	LOSS OF VACUUM		PLISHED, NOT TO BE USED FOR
K	MINOR INSPECTION	989	LOW COOLANT FLOW RATE		STANDBY, AWAITING WORK ASSIGN-
L	DURING TRAINING OR MAINTENANCE ON	004	LOW GM OR EMISSION		MENTS, LAG, OR OTHER DELAYS,
	EQUIPMENT UTILIZED IN A TRAINING	962	LOW POWER-ELECTRONIC		OR WHEN DIRECT PRODUCTIVE EFFORT
	ENVIRONMENT. (USE ONLY FOR CLASS	537	LOW POWER OR THRUST		IS BEING EXPENDED.
	II TRAINING EQUIPMENT). THIS CODE	386	MAINTENANCE ACTION DUE TO LOST IN		
	SHOULD BE USED WHEN RECORDING		FLIGHT OCCURRENCE		
	MAINTENANCE OR DISCREPANCIES ON	372	METAL ON MAGNETIC PLUG	CNP00	COMPENSATORY TIME FOR OVERTIME -
	CLASS II TRAINERS.	009	MICROPHONIC		
M	PHASED/ISOCHRONAL/MAJOR	092	MISMATCHED-WHEEL HALVES, ELECT-		ALL DIRECT ASSIGNED MANHOURS
P	FUNCTIONAL CHECK FLIGHT		RONIC PARTS, ETC.		EXCUSED FROM NORMAL DUTY AS A
Q	SPECIAL INSPECTION (INCLUDES CIE)	750	MISSING		RESULT OF PREVIOUSLY EXPENDED
R	QUALITY CONTROL CHECK	106	MISSING BOLTS, NUTS, SCREWS,		OVERTIME MANHOURS.
S	DEPOT LEVEL MAINTENANCE		RIVETS, FASTENERS, CLAMPS OR		
T	DURING SCHEDULED CALIBRATION	425	OTHER COMMON HARDWARE		
U	NON-DESTRUCTIVE INSPECTION, IN-	799	NICKED	07100	DETAIL, SQUADRON OR BASE
	CLUDES OPTICAL, PENETRANT, MAG-	800	NO DEFECT		DUTIES -
	NETIC PARTICLE, RADIOGRAPHIC, EDDY		NO DEFECT - COMPONENT REMOVED AND		
	CURRENT, ULTRASONIC, SPECTROMETRIC		OR REINSTALLED TO FACILITATE OTHER		MANHOURS EXPENDED BY DIRECT
	OIL ANALYSIS, ETC.		MAINTENANCE		LABOR PERSONNEL (LABOR CODE 100)
		812	NO DEFECT - INDICATED DEFECT		PERFORMING ON-BASE DUTIES SUCH
			CAUSED BY ASSOCIATED EQUIPMENT		AS CO, POLICING, BUILDING MAI-
			MALFUNCTION		TENANCE, DRIVER, DINING HALL,
		805	NO DEFECT - NOT OTHERWISE CODED,		PARADE, COMMANDERS CALL, GENERAL
			ELECTRICAL, HYDRAULIC, AIR, FUEL,		MILITARY TRAINING, NON-TECHNICAL
			OXYGEN, OIL, ETC. LINES, MECHAN-		TRAINING, ETC.
			ICAL LINKAGE AND CABLES SERVICING		
			A COMPONENT REMOVED/DISCONNECTED		
			AND/OR INSTALLED/CONNECTED TO		
			FACILITATE OTHER MAINTENANCE		
		948	NO DEFECT - OPERATOR ERROR	LVE00	LEAVE -
		802	NO DEFECT - PARTIAL TECHNICAL		
			ORDER COMPLIANCE		MANHOURS EXCUSED FROM DUTY,
		804	NO DEFECT - REMOVED FOR SCHEDULED		PASS, OR OFFICIAL LEAVE.
			MAINTENANCE OR MODIFICATION		MILITARY, MEDICAL OR SICK LEAVE.
		803	NO DEFECT - REMOVED FOR TIME		
			CHANGE		

G

WORK UNIT CODE

13000	LANDING GEAR
13100	MAIN LANDING GEAR (CONTINUED)
13126	CONTROL VALVE
13127	DUMP VALVE
13128	SELECTOR VALVE
13199	NOC
13200	HOSE GEAR
13210	MECHANICAL COMPONENTS
1321A	TORQUE SCISSOR, LOWER
1321B	DISCONNECT HANDLE
1321C	TOW FITTING
1321D	BEARING ANTI-FRICTION
1321E	BUSHING
1321F	UPLOCK
1321G	DOWNLOCK
1321H	HOSE GEAR CRANK
1321K	DRAG FITTING STRAP PN 337664-84
1321N	BRACE ASSY-DRAG
1321P	DRAG LINK BEARING INSERT
1321Q	STEERING COLLAR
1321R	TRUNNION
1321S *	TOW FITTING ATTACHING BOLT (TCI)
1321T	AXLE
1321U	CYLINDER-FULCRUM ONE PIECE
1321V	STRUT
1321W	PISTON
1321X	LINK DRAG
1321Y	DISCONNECT PIN
1321Z	FULCRUM
13220	FILLER VALVE
13221	SIDE STRUT
13222	TORQUE SCISSOR, UPPER
13223	HYDRAULIC COMPONENTS
13224	SHUT-OFF VALVE
13225	CYLINDER ACTUATOR
13226	UPLOCK CYLINDER
13227	DOWNLOCK CYLINDER
13228	PRESSURE REDUCER VALVE
13229	RELIEF VALVE
13230	RESTRICTOR
13231	CHECK VALVE
13232	SHUTTLE VALVE
13299	NOC
13300	ELECTRICAL COMPONENTS, LANDING GEAR
13310	MAIN GEAR
1331A	INDICATOR-POSITION, RIGHT
1331C	TWO SPEED CONTROL BOX
1331E	WARNING HORN

13-002

Foldout 1. IC-130-06 (extract).

S T O P -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
42354 01 21
SHOP ADMINISTRATION

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

42354-01-21

MULTIPLE CHOICE

1. (001) Which of the following is not indicated in an Air Force Specialty Code?
 - a. The career field.
 - b. The career field subdivision.
 - c. The rank.
 - d. The skill level.
2. (002) What is the purpose of the specialty description?
 - a. To list the jobs required for upgrading to the next highest skill level.
 - b. To describe the breakdown of the Air Force Specialty Codes.
 - c. To describe the duties, responsibilities, and special qualifications needed to perform duties in a given AFS.
 - d. To show the proficiency and knowledge level required when conducting OJT.
3. (003) An individual requiring close supervision during training on the job would be at the
 - a. 3 skill level.
 - b. 5 skill level.
 - c. 7 skill level.
 - d. 9 skill level.
4. (004) Each of the following is a route by which an individual may obtain a 3 skill level except
 - a. qualification as a bypassed specialist.
 - b. qualification by direct duty assignment proficiency training.
 - c. completion of a formal training course.
 - d. completion of a related course at a college level.
5. (005) One of the main features of the WAPS program is its visibility. What exactly does this mean?
 - a. It shows what areas you should study.
 - b. It lets you know exactly what you're being judged on, in comparison with others of the same grade in your AFS.
 - c. It lets your commander promote deserving airman on his recommendation.
 - d. It aids the supervisor to visually determine if you have achieved a certain proficiency level.

42354-01-21

6. (006) In determining training needs, the first thing that must be ascertained is
- specifically what the trainee must do to accomplish his job effectively and completely.
 - the availability of training material.
 - who will do the actual training.
 - the trainee's job preference.
7. (007) On-the-job training involves
- duties and tasks.
 - formal and informal training.
 - self-study and supervised instruction.
 - supervisory abilities and training capabilities.
8. (008) Which of the following is not a responsibility of the immediate supervisor in conducting OJT?
- Administering course examinations.
 - Selecting qualified trainers.
 - Certifying job proficiency.
 - Recommending trainee's for upgrading.
9. (009) The most effective training method in OJT is
- lecture.
 - discussion.
 - demonstration.
 - performance.
10. (009) To prepare a training situation, you should
- make sure that equipment is available.
 - demonstrate the correct method.
 - put the trainee at ease.
 - check the trainees work progress.
11. (010) Which of the following is the most accurate statement about AF Form 623?
- It contains a cumulative and consolidated account of an airman's knowledge and proficiency training.
 - It is primarily useful in recording individual interests and preferences.
 - It is useful mainly to record academic and learning ability scores.
 - It provides a comprehensive personality assessment of the airman.

12. (010) In which section of the AF Form 623 would completion of an NCO leadership school be recorded?
- a. In Section I, Identification Data.
 - b. In Section II, Orientation and Certification.
 - c. In Section IV, ECI/CDC Participation, Etc.
 - d. In Section V, Technical and Supervisory Training.
13. (011) When an annotated Specialty Training Standard is inserted in the AF Form 623, it is called a
- a. specialty description.
 - b. continuation sheet.
 - c. job proficiency guide.
 - d. plan of instruction.
14. (012) Within how many months after regular Air Force graduates of a formal technical school will personnel from the training activities visit the bases?
- a. 3 months.
 - b. 6 months.
 - c. 9 months.
 - d. 12 months.
15. (012) As supervisor of the pneudraulic shop you notice that personnel graduating from the Pneudraulic Technical School cannot perform a certain task to the level specified in the STS. How should you bring this fact to the attention of the training center?
- a. By requesting a field evaluation visit.
 - b. By initiating a direct correspondence questionnaire.
 - c. By completing a trainee questionnaire.
 - d. By submitting a Training Quality Report (AF Form 1284).
16. (013) Why is it essential that some official information be classified?
- a. For the security of the Air Force.
 - b. For the security of the Nation and the safety of our people and our allies.
 - c. It is essential only because the regulations require this information.
 - d. For the security of the armed forces.
17. (014) The unauthorized disclosure of confidential information could result in
- a. exceptionally grave danger to the national security.
 - b. serious damage to the national security.
 - c. damage to the national security.
 - d. the disruption of foreign training.

18. (014) Unclassified information that may be withheld from a widespread distribution to the public is termed
- a. Confidential information.
 - b. For Official Use Only information.
 - c. Secret information.
 - d. Top Secret information.
19. (015) Which of the following directives should a supervisor use when briefing personnel on security matters?
- a. DOD 5200.1-R and AFR 205-1.
 - b. AFM 127-101 and AFR 205-1.
 - c. AFM 127-101 and DOD 5200.1-R.
 - d. AFM 67-1 and 66-1.
20. (016) Classified documents can be identified by markings
- a. at top of title page only.
 - b. at bottom of title page only.
 - c. on the envelope containing the documents.
 - d. at the top and bottom of each page of the document.
21. (017) An Air Force method of communication that is fast but insecure is the
- a. Automatic Secure Voice Network (AUTOSEVOCOM).
 - b. Automatic Digital Network (AUTODIN).
 - c. Automatic Voice Network (AUTOVON).
 - d. US Registered Mail.
22. (018) An important rule to remember when using the telephone is to
- a. make sure the other person on the line has a need to know.
 - b. avoid discussing classified matters on the telephone.
 - c. tell the other person the classification of the information.
 - d. keep classified information brief and to the point.
23. (018) Attempting to disguise or conceal the meaning of classified information in a telephone conversation is known as
- a. "compromising."
 - b. "falsification."
 - c. "talking around."
 - d. "comparing with unlike subjects."
24. (019) The term "clandestine sabotage" means
- a. spying openly.
 - b. secretly destroying material.
 - c. openly destroying equipment.
 - d. spying secretly.

42354-01-21

25. (020) Which of the following best describes the exchange badge procedure?
- a. It requires the issuance of two badges.
 - b. It involves only one badge.
 - c. It involves the notification of central security control.
 - d. Personnel are asked to sign their name which will be compared against their other credentials.
26. (021) If the capital letter E is typed to the side of the numbers on the restricted area badge, this indicates
- a. an enlisted person.
 - b. an escort official.
 - c. an essential supervisor.
 - d. an essential person.
27. (022) OPSEC involves the protection of
- a. all classified information from disclosure to the enemy.
 - b. classified and unclassified information about a military operation that could aid the enemy if revealed.
 - c. operational resources from the enemy.
 - d. weapon storage facilities.
28. (022) One of the major objectives of the OPSEC program is to
- a. identify the portions of an operation needing protection.
 - b. classify all the information concerning an operation.
 - c. secure all methods of communication affecting an operation.
 - d. secure all the facilities on the flight line.
29. (023) The success or failure of an operation is contingent upon the
- a. weaknesses of each individual.
 - b. number of personnel involved.
 - c. number of weapons involved.
 - d. element of surprise.
30. (024) What security program deals with the protection of Air Force operational resources?
- a. COMSEC.
 - b. OPSEC.
 - c. Physical Security.
 - d. Information Security.
31. (025) Which of the following might indicate an operation?
- a. A change in flight activity.
 - b. A change in shift schedule at supply.
 - c. The use of unchanging call signs.
 - d. All of the above.

32. (026) Information within your shop that would require protection is
- a. a toolbox list.
 - b. the number of personnel on TDY.
 - c. a bench stock inspection date.
 - d. the number of a particular job.
33. (027) What type of publications are issued by Headquarters USAF?
- a. Field.
 - b. Air Force.
 - c. Departmental.
 - d. Department of Defense.
34. (027) Although operating instructions are similar to regulations, they
- a. need not comply with higher level directives.
 - b. are issued only at command headquarters level.
 - c. are used in connection with announced notices or programs.
 - d. must comply with existing higher level directives and be kept current.
35. (028) The second number preceded by a dash on regulations, manuals, and pamphlets is a means for
- a. accurate filing.
 - b. identifying the priority.
 - c. identifying the basic subject.
 - d. identifying a more specific area of a subject.
36. (029) To determine the prescribing directive for a specific form used in the maintenance of aircraft, in what standard publication index should you look?
- a. AFR 0-9.
 - b. AFR 0-7.
 - c. AFR 0-3.
 - d. AFR 0-2.
37. (030) If you are checking the index of standard publications and you notice a red minus (-) symbol written on the left margin in front of a regulation, you should realize that this symbol means
- a. a current copy of this regulation is being published.
 - b. additional copies of this regulation have been requested.
 - c. a current copy of this regulation is not on hand.
 - d. the original copy of this regulation has been destroyed.

38. (031) With reference to TO number 1F-4C-2-6, the "-2" designates the
- a. kind of TO.
 - b. TO supplement.
 - c. numerical listing.
 - d. type of aircraft.
39. (032) Which of the following publications is generally referred to as the index of indexes?
- a. TO 0-1-01.
 - b. TO 00-5-1.
 - c. TO 0-1-4.
 - d. TO 0-2-1.
40. (032) The alphabetical index (TO 0-2-1) provides a means for
- a. keeping TOs current.
 - b. listing types of equipment.
 - c. establishing TO requirements.
 - d. locating the correct TO number group.
41. (033) In technical manuals, which of the following is an illustrated parts breakdown manual?
- a. The -01 TO.
 - b. The -2 TO.
 - c. The -4 TO.
 - d. The -6 TO.
42. (034) If you wanted to find the TO used to overhaul a hydraulic unit, which of the following TOs should you use to locate this TO?
- a. -01.
 - b. -06.
 - c. -3.
 - d. -6.
43. (034) When using an illustrated parts breakdown on a hydraulic unit you notice a column heading titled "Useable on Code." What does this heading indicate?
- a. It lists the number of identical parts used on a major assembly.
 - b. It identifies the name of the company that made the part.
 - c. It tells you which unit the part will fit when the TO covers more than one unit.
 - d. It identifies the maintenance activity authorized to perform maintenance.
44. (035) For a condition that could create a hazard through prolonged usage, what type of Time Compliance Technical Order would the Air Force issue?
- a. Immediate action.
 - b. Routine action.
 - c. Urgent action.
 - d. Interim.

45. (036) Workcards, sequence charts, and checklists should be classified as what type of Technical Order?
- a. Methods and procedures.
 - b. Functional.
 - c. Sectional.
 - d. Abbreviated.
46. (036) An example of a methods and procedures TO is
- a. IC-130B-1 (Flight Manual).
 - b. 00-25-223 (Integrated Pressure Systems and Components).
 - c. IC-130B-2CL-3 (Aircraft Jacking).
 - d. 1-1A-8 (Aircraft Structural Repair).
47. (037) Which AFTO form is used to list the contents in a standard technical order binder?
- a. AFTO Form 10.
 - b. AFTO Form 22.
 - c. AFTO Form 29.
 - d. AFTO Form 32.
48. (038) In accordance with standardization agreements reached among military departments, the term "revision"
- a. applies to a complete new edition of an existing publication.
 - b. is used to identify the changed parts of an existing publication.
 - c. is used to indicate a change in the TIT/R and introductory statement.
 - d. has been replaced by the word "republication."
49. (038) Safety and operational supplements to Technical Orders should be filed in
- a. a separate TO binder in Quality Control.
 - b. a separate TO binder in the TO library.
 - c. numerical sequence by date in the front of the basic TO.
 - d. numerical sequence by date in the back of the basic TO.
50. (039) Who has the primary responsibility for initiating a report of a deficiency in a Technical Order?
- a. The shop chief.
 - b. The quality control section.
 - c. The maintenance officer.
 - d. The individual who discovers the deficiency.
51. (040) The SMO is responsible for the control and issue of
- a. nonexpendable items only.
 - b. repair parts and maintenance items.
 - c. clothing.
 - d. tools.

52. (041) The National Stock Number consists of two distinct portions, which are the
- a. national supply classification (NSC) and the national item identification number (NIIN).
 - b. part number and the stock number.
 - c. reference number and the national stock class (NSC).
 - d. national codification bureau (NCB) and the national supply classification (NSC).
53. (041) If you order an item from supply and the ERRC code is XB3, what does this code indicate?
- a. A repair cycle asset item.
 - b. A high value item that cannot be condemned.
 - c. An item more than \$10 that can be repaired.
 - d. An item of less than \$10 which can be expended at base level.
54. (042) Which copy of the DD Form 1348- (Single Line Item Release/ Receipt Document) is attached to the AFTO Form 350?
- a. Copy 1.
 - b. Copy 2.
 - c. Copy 3.
 - d. Copy 4.
55. (043) Part II of the AFTO Form 350 is used as a
- a. production scheduling document.
 - b. repair cycle processing tag.
 - c. maintenance data collection record.
 - d. serviceable parts tag.
56. (044) A Quick Reference List (QRL) will include only
- a. fast moving, high usage items.
 - b. critical items in short supply for which there is excessive demand.
 - c. expendable items that show a repetitive consumption only.
 - d. repair cycle asset items that are due-in-from-maintenance.
57. (044) Which of the following forms is used in ordering parts from supply?
- a. AF Forms 349 and 350.
 - b. AF Forms 1577 and 1577-2.
 - c. AF Forms 350 and 2005.
 - d. AF Forms 2005 and 2413.

58. (045) If you found a due-out card in a bench stock bin, what would this indicate?
- a. That the bench stock item has been deleted from bench stock.
 - b. That the bench stock item is on order.
 - c. That an inventory has just been completed.
 - d. That these items are of a sensitive nature and must be properly guarded.
59. (046) The shelf-life of a bench stock item can be found on the
- a. stock listing record.
 - b. critical item listing.
 - c. quick reference list.
 - d. bench stock label.
60. (047) Which of the following tags would be placed on a floor buffer to indicate it is a serviceable unit?
- a. AFTO Form 350.
 - b. DD Form 1574.
 - c. DD Form 1577-2.
 - d. DD Form 1577.
61. (047) If an item is unserviceable, but you are going to keep and repair it yourself, where should you list the open discrepancy, parts, and supply document numbers back-ordered?
- a. On the AFTO Form 350.
 - b. On the back side of the green tag DD Form 1577-2.
 - c. In the reason block of green tag DD Form 1577-2.
 - d. On the back side of the red tag DD Form 1577.
62. (048) Who is charged with the responsibility for the care and safeguarding of property?
- a. The commander.
 - b. The shop supervisor.
 - c. The branch supervisor.
 - d. The individual using the property.
63. (048) The three types of property responsibility which may be imposed on officers, airmen, and civilians are
- a. supply, shop, and command.
 - b. shop, command, and custodial.
 - c. command, custodial, and supervisory.
 - d. custodial, departmental, and supervisory.
64. (049) In the instance of property rendered unserviceable through fair wear and tear, relief from property responsibility may be obtained by
- a. initiating a report of survey.
 - b. turning it in to authorized channels.
 - c. preparing a certificate of destruction.
 - d. transferring it to a using organization.

42354-01-21

65. (049) When a shop supervisor ships out and his replacement has not arrived, who will be responsible for the property under his control?
- a. The next higher supervisor.
 - b. The commander.
 - c. His assistant.
 - d. The replacement even though he hasn't yet arrived.
66. (050) What are two forms used to reimburse the Air Force when pecuniary liability is admitted and the cost of the item does not exceed \$250?
- a. DD Forms 1120 and 349.
 - b. DD Forms 1131 and 349.
 - c. DD Forms 362 and 1131.
 - d. DD Forms 362 and 1120.
67. (051) Which of the following is not one of the steps in the Maintenance Data Collection System (MDC)?
- a. Forecasting.
 - b. Collecting.
 - c. Storing.
 - d. Retrieving.
68. (051) The maintenance data collection system at base level contains information on all of the following except
- a. how many man-hours were expended by each work center.
 - b. the work center that did the job.
 - c. which people in each work center require training.
 - d. the equipment on which the work was accomplished.
69. (052) Which of the following is not a maintenance data collection documentation category?
- a. On-equipment.
 - b. Off-equipment.
 - c. Non-productive.
 - d. Productive indirect.
70. (052) When used for a TCTO, the paper color of an AFTO Form 349 would be
- a. green.
 - b. blue.
 - c. yellow.
 - d. pink.
71. (053) The Equipment Classification (EQ/CL) code identifies
- a. a specific piece of equipment.
 - b. a general class of equipment.
 - c. a general class and specific type of equipment.
 - d. only airborne equipment.

72. (053) When filling out an AFTO Form 349, in which of the following columns would you enter the type maintenance code that identifies the type of maintenance performed?
- a. N.
 - b. C.
 - c. J.
 - d. A.
73. (054) In which of the following labor reporting categories would a commander's call fall?
- a. In productive direct.
 - b. In productive indirect.
 - c. In on-equipment.
 - d. In non-productive.
74. (055) What is the minimum signature used on most maintenance forms?
- a. The first name initial, complete last name, and rank or grade.
 - b. The first name, middle initial, and complete last name.
 - c. The complete last name and rank.
 - d. The first name initial, middle initial, complete last name, and rank or grade.
75. (056) The maintenance symbol which indicates the equipment is unsafe and should not be used is a
- a. red diagonal.
 - b. red dash.
 - c. red X.
 - d. black last name initial.
76. (056) Which maintenance symbol is used to indicate that an Urgent Action TCTO is overdue?
- a. A red X.
 - b. A red dash.
 - c. A red diagonal.
 - d. A circled red X.
77. (057) A purpose of AFTO Form 781A is to
- a. document aircraft time.
 - b. identify discrepancies discovered.
 - c. document the aircraft maintenance status.
 - d. continue the AFTO Form 781K, Calendar Inspection Record.

78. (057) Once a routine discrepancy has been corrected that does not require an inspection, the mechanic who accomplished the task will enter which of the following on AFTO Form 781A?
- a. He will sign the Corrected By block and enter his grade and man-number.
 - b. He will sign the Corrective Action block and place his initial over the symbol.
 - c. He will sign the Corrective Action block, and have a 7-level specialist sign the Inspected By block.
 - d. He will sign the Corrective Action block, place his initial over the symbol, then have a 7-level specialist sign the Inspected By block.
79. (058) Which of the following entries can not be entered in block H of AFTO Form 781K?
- a. A red X and red diagonal.
 - b. A red dash and red diagonal.
 - c. A red X and circled red X.
 - d. A red dash and circled red X.
80. (059) In which AFTO Form 781 series is the current status of an aircraft recorded?
- a. In 781.
 - b. In 781A.
 - c. In 781H.
 - d. In 781K.
81. (060) Which form is used as a record of cannibalization actions?
- a. AF Form 349.
 - b. AF Form 350.
 - c. AF Form 781K.
 - d. AF Form 991.
82. (061) After checking AFTO Form 443, a mechanic on the flight line tried to start an air compressor and the starter motor fell off. What could this indicate?
- a. The mechanic should also have checked the AFTO Form 444 for discrepancies.
 - b. This is a common occurrence among air compressors.
 - c. The mechanic should also have checked the 781A for discrepancies.
 - d. The mechanic was not trained properly in starting the air compressor.
83. (062) An aircraft strut broke on landing thereby causing fire. An inspection of the whole fleet of aircraft revealed four other struts were cracked. Which of the following would be used to report this incident?
- a. AFTO Form 991.
 - b. AFTO Form 22.
 - c. A Category II report.
 - d. A Category I report.

84. (063) What is the highest military position in the chain of command?
- a. The Secretary of Defense.
 - b. The Air Force Chief of Staff.
 - c. The Secretary of the Air Force.
 - d. The Air Force Commander-in-Chief.
85. (064) Depot level maintenance consists of
- a. preflight inspections and manufacturing needed parts.
 - b. tests and repairs.
 - c. servicing and preventive maintenance.
 - d. major overhauls.
86. (065) The Chief of Maintenance controls, schedules, and monitors operations within the maintenance complex through
- a. staff agencies.
 - b. job control.
 - c. plans and scheduling.
 - d. maintenance control.
87. (066) All of the following are functional elements of maintenance control except for
- a. job control.
 - b. plans and scheduling and documentation.
 - c. production analysis.
 - d. materiel control.
88. (067) The primary technical advisory staff agency in the maintenance activity is
- a. maintenance control.
 - b. quality control.
 - c. production control.
 - d. materiel control.
89. (068) What is the overall objective of production analysis?
- a. To procure parts from supply.
 - b. To control the inspections of aerospace vehicles.
 - c. To control all reparable assets within the maintenance complex.
 - d. To provide information to be used to improve the maintenance operation.
90. (069) A recurring special certification of egress training on a particular aircraft would be classified as
- a. OJT.
 - b. qualification training.
 - c. management training.
 - d. upgrade training.

91. (070) Which agency under the Deputy Commander for Maintenance will monitor maintenance manning authorizations of the maintenance complex?
- a. Maintenance Control.
 - b. Production Control.
 - c. Management Administration.
 - d. Programs and Mobility.
92. (071) Which of the following statements describes a function of the organizational maintenance squadron?
- a. Providing maintenance and specialist assistance to other maintenance squadrons.
 - b. Maintaining short-range attack missiles.
 - c. Having physical charge of the assigned aircraft.
 - d. Maintaining the communication equipment and other electronic systems.
93. (072) Which of the following sections would be directly affected by knowing the time a job started and the time the job was completed when using MIMICS?
- a. The documentation section.
 - b. Job Control.
 - c. Programs and Mobility.
 - d. Training management.
94. (073) If you are assigned to troubleshoot a malfunctioning pneudraulic system on an aircraft, in which of the following section would you most likely be assigned to?
- a. In the flight line section.
 - b. In the inspection section.
 - c. In the in-shop section.
 - d. In the brake repair section.
95. (074) When constructing an organizational chart, how many levels above and below the charted position should you show on the chart?
- a. One above and one below.
 - b. One above and two below.
 - c. Two above and one below.
 - d. Two above and two below.
96. (075) The coordination of work with other shops is usually done through
- a. job control.
 - b. the flight line supervisor.
 - c. plans and scheduling.
 - d. production control.

97. (076) The prime concern of a supervisor when planning and scheduling work is the
- a. priority.
 - b. workload flow.
 - c. cost factor.
 - d. overtime required.
98. (077) The selection of a specialist to accomplish a difficult task should be based on his
- a. grade.
 - b. age.
 - c. time in service.
 - d. job knowledge.
99. (078) In reviewing a completed assignment with an individual you supervise, you should
- a. criticize sloppy work and reaccomplish it yourself.
 - b. stress the weak points of the work.
 - c. praise work done skillfully and point out weak points.
 - d. have the job reaccomplished as many times as may necessary until it is done right.
100. (079) Completed maintenance data collection forms (AFTO Form 349) are kept on file in
- a. the responsible shop.
 - b. job control.
 - c. quality control.
 - d. The administrative Section.
101. (079) Graphs should
- a. be complicated.
 - b. be eliminated.
 - c. be easy to read.
 - d. contain 6 items or more.
102. (080) Which of the following is hardest to rate fairly when preparing a performance report?
- a. The average worker.
 - b. The poorest worker.
 - c. The above average worker.
 - d. The 3-level specialist.
103. (081) When justifying increased manpower, which of the following questions would the supervisor not consider?
- a. Will the condition be temporary?
 - b. Are tasks assigned to proper section?
 - c. Are TDY assignments compiled correctly?
 - d. Does the shop have the required equipment?

104. (082) What should you do when a subordinate asks you a question about a job for which you have no answer readily available?
- a. Distract him for the time being and get the answer later.
 - b. Guess at the answer, look it up when you can, and if you were wrong then set him straight.
 - c. Admit that you don't know and offer to help him find the answer.
 - d. Tell him not to worry about it, and that you will take care of things like that.
105. (083) Having the individual restate his problem will sometimes
- a. suggest a solution.
 - b. make the worker angry.
 - c. use up valuable time.
 - d. make the individual feel depressed.
106. (083) The following basic steps are all a part of problem solving, except to
- a. get the facts.
 - b. take action.
 - c. brief other workers.
 - d. weigh and decide.
107. (084) An AF Form 1000 is used to
- a. submit grievances.
 - b. submit suggestions.
 - c. submit hazard reports.
 - d. rate performances.
108. (085) Which of the following are considered to be the direct causes of any accident?
- a. Unsafe acts and natural phenomena.
 - b. Unsafe acts and conditions.
 - c. Unsafe conditions and natural phenomena.
 - d. Unsafe acts and impatience.
109. (086) What type of container should be used for combustible wastes?
- a. Any container that has a metal lid.
 - b. Any container that has a self-closing lid.
 - c. Any container marked for "Clean Rags Only."
 - d. Only a metal container that has a self-closing lid.
110. (087) A fire can be extinguished by removing each of the following except
- a. fuel.
 - b. oxygen.
 - c. carbon dioxide.
 - d. heat.

111. (088) Which of the following types of fire extinguishers smothers and cools a fire?
- a. Foam.
 - b. Chlorobromomethane.
 - c. Dry chemical.
 - d. CO₂.
112. (089) Which of the following conditions may arise if improper ventilation is used while working with cleaning solvents over a prolonged period?
- a. The individual may incur liver or kidney damage.
 - b. A probable hazard of a fire will exist.
 - c. The solvent will evaporate.
 - d. The solvent may explode.
113. (090) When working near any electrical potential, you should not
- a. turn the power off if you detect smoke.
 - b. use plastic handled screwdrivers.
 - c. work on a circuit unless the power is on.
 - d. wear rings, watches, or metal rimmed glasses.
114. (091) It has been estimated that the intestines may be ruptured with what amount of air pressure?
- a. 2 psi.
 - b. 4 psi.
 - c. 6 psi.
 - d. 8 psi.
115. (092) When lifting an object lower than your waist, you should
- a. assume a squatting position and, with your back straight, allow your back to exert the lifting force.
 - b. lift with your arms only.
 - c. lift with your back only.
 - d. assume a squatting position and, with back straight, allow your legs to exert the primary lifting force.
116. (093) A device for monitoring the amount of radiation a person may receive is a
- a. beta emitter.
 - b. dosimeter.
 - c. radiac instrument.
 - d. special X-ray machine.
117. (094) What should you do to avoid the danger of radio-frequency radiation?
- a. Take shelter.
 - b. Don't stand in the beam of a radar antenna.
 - c. Decontaminate as soon as possible after exposure.
 - d. Wear protective clothing.

118. (095) To prevent the accidental arming and firing of the ejection seat, safety pins are installed
- a. immediately after each flight.
 - b. by egress personnel.
 - c. before each flight.
 - d. with red and blue streamers attached.
119. (095) What should you, as a mechanic, do to prevent foreign object damage (FOD)?
- a. Be sure that all parts of the cockpit are secure.
 - b. Use a locally prepared checklist for each tool and other object.
 - c. Secure your tools in the proper cockpit compartment.
 - d. Inventory your tools weekly.
120. (096) A red stripe is painted around the fuselage and jet engine nacelle on an aircraft to indicate the location of the
- a. engine exhaust outlet.
 - b. engine air inlet zone.
 - c. turbine wheel danger zone.
 - d. fire access doors.
121. (096) What is the minimum safe distance that a person should stand from the engine intake duct on a jet aircraft during an engine operation?
- a. 10 feet.
 - b. 15 feet.
 - c. 25 feet.
 - d. 50 feet.
122. (097) Which of the following is often a symptom of noise fatigue?
- a. A severe rash.
 - b. Extreme elation.
 - c. Sleepiness.
 - d. Emotional irritability.
123. (098) Before operating any power actuated control surfaces on an aircraft, be sure the
- a. ground safety locks have been removed.
 - b. system pressure is normal and adequate.
 - c. area is clear of personnel and equipment.
 - d. areas not being worked on have been properly covered.
124. (099) From which direction should you approach an overheated wheel?
- a. From the tail or nose direction.
 - b. In line with the wheel axle.
 - c. It doesn't matter from which direction you approach the wheel.
 - d. You should never approach an overheated wheel; call the fire department instead.

42354-01-21

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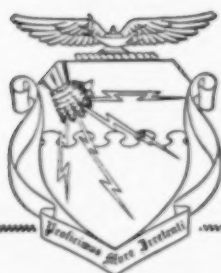
CDC 42354

AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC

(AFSC 42354)

Volume 2

Pneudraulic Fundamentals, Materials and Equipment



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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND
IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS SECOND volume of CDC 42354, *Aircraft Pneudraulic Systems Mechanic*, contains information on pneudraulic fundamentals, materials and equipment. This information has intentionally been kept simple, but yet in enough detail to fulfill the requirements of the STS. The first chapter reviews information on the fundamentals of pneudraulics and electricity. The second chapter contains information on the various materials (seals, hose, fitting, etc.) that you as a pneudraulic mechanic will more than likely come in contact with while performing your job. The third chapter covers information of a general nature on the tools you will be using. The fourth and fifth chapters are on nonpowered and powered aerospace ground equipment. Not all AGE can be covered in these two chapters so we have selected several representative units of the equipment you will be using. The sixth chapter covers equipment that is most commonly found in the pneudraulic shop, such as hydraulic test stands, hose cutoff and assembly machines.

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This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of July 1977.

Contents

	<i>Page</i>
<i>Preface</i>	iii
<i>Chapter</i>	
1 Fundamentals of Pneudraulics and Electricity	1
2 Pneudraulic Systems Materials	25
3 Maintenance Tools	61
4 Test Instruments and nonpowered Aerospace Ground Equipment	91
5 Powered Aerospace Ground Equipment	111
6 Shop Equipment	139
<i>Answers for Exercises</i>	159

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Fundamentals of Pneudraulics and Electricity

THIS CHAPTER covers pneudraulic fundamentals, and the application of these fundamentals to transmit force from one part of an aircraft to another. We will also be concerned with the electrical fundamentals encountered in pneudraulic systems. As pneudraulic specialists, an understanding of pneudraulic fundamentals can help solve maintenance problems that may seem unsolvable. It may appear that one does not need to know about fundamentals when an actuator is leaking. But what if the actuator moves one way and not the other when pressure is applied. Or, how about the flight controls that move erratically, or the valve that ruptures. What causes these problems? These questions can be answered in most cases by understanding the fundamentals of pneudraulics.

1-1. Pneudraulic Fundamentals

Years ago, man found that the force of moving water and wind could do great damage. However, he also learned that if he controlled these forces, he could make them work for him. For instance, he used the waterwheel to grind his grain, and the windmill to irrigate his fields. When the waterwheel and the windmill were first introduced, man probably did not realize that he was using principles that would someday be used to provide power for highly complex machinery.

Hydraulics is the branch of mechanics that deals with the practical applications of liquids in motion. It comes from the Greek word "hydro" that means "water." Pneumatics, the branch of mechanics that deals with the mechanical properties of gases, comes from the Greek word "pneumo" that means "air or gas." Combining these two words produces the word "pneudraulics," which is the branch of mechanics that deals with liquids and gases.

200. Define Boyle's and Charles's gas law, and specify how Pascal's law applies to a hydraulic system.

Pneudraulic Fundamentals. When applied to aircraft, the term "pneudraulics" is used to describe a method of transmitting a force from one place to another through the use of a fluid. To understand this, you must understand certain characteristics of fluids. A fluid is any substance that flows freely and takes the shape of its container. A fluid can be a liquid or a gas. What is the difference between the two? First, a gas fills its container completely, while a liquid remains at the bottom. As an example, pour a quart of water into a gallon bucket. Because the quart of water cannot fill the bucket completely the water takes the shape of the buckets bottom. Now take the same amount of gas (air) and put it into the bucket. The gas doesn't just settle at the bottom of the bucket, it completely fills the bucket, and may even overflow the rim of the bucket. Second, gases are lighter than equal amounts of liquids. If a bucket is filled with a liquid, we know it is heavier than the bucket that is filled with a gas. Third, gases are highly compressible, but for all practical purposes, liquids are not. Only under extremely high pressures can a liquid be compressed, then only slightly. This is shown in figure 1-1, A and B. Notice that the molecules of a liquid are like a bunch of marbles in a coffee can. If you tried to compress the molecules of liquid, it will be extremely hard to do so, because they are so compact.

Boyle's law. The English scientist Robert Boyle was among the first to study the compressibility of gases, which he called the "springiness of air." Boyle's law is normally stated: "The volume of an enclosed dry gas varies inversely with its pressure,



A



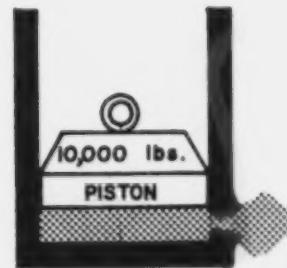
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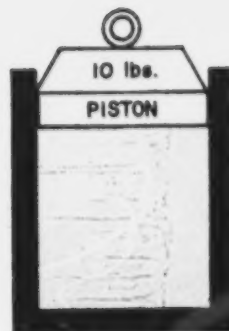
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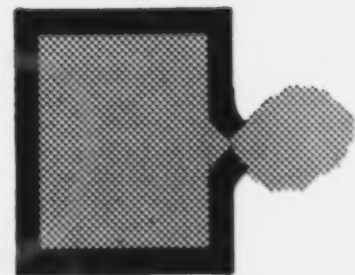
E



F



G



42-1842

H

Figure 1-1. Pneumatic fundamentals.

provided the temperature remains constant." This law can be demonstrated by confining a quantity of gas in a cylinder that has a tight fitting piston. See figure 1-1, C. Notice that the molecules of gas are far apart, much like a bunch of balloons floating in the air. When the force applied to the piston is doubled, the gas is compressed to one-half its original volume, as shown in figure 1-1, D. Of course, as the force on the piston is increased the pressure will also increase. If the force pushing down (see figure 1-1, E) creates so much pressure that it exceeds the design capabilities of the container, then the container will surely burst.

Charles's law. A Frenchman, Jacques Charles was another scientist that experimented with gases. He found that all gases expand and contract in direct proportion to the change in the temperature, provided the pressure remains constant. This law is shown in figure 1-1, F and G. Let's assume that the container in figure 1-1, F, is at room temperature. As the temperature is increased (simulated by the lighted candle), the gas expands, as shown in figure 1-1, G. Even though the gas did expand, the pressure remained the same. The reason for this is that the piston was pushed up along with the expanding gases.

In contrast let's take a look at a gas (or liquid) that is completely confined. (See figure 1-1, H. As the candle heats the gas (or liquid) inside the container, the gas (or liquid) will expand. This causes the pressure to increase, because the gas (or liquid) has no place to go. If the gas (or liquid) continues to expand and the pressure exceeds the design capabilities of the container, it too will burst.

Pascal's law. Both mathematical calculations and their practical application in working hydraulic systems are based upon this law. Blaise Pascal (1623-1662) was a noted French mathematician and philosopher whose law is stated as follows: When a force is exerted on a confined fluid, the pressure is transmitted equally and undiminished in all directions. Pay particular attention to the words "force" and "pressure." From now on, they, and other terms, must be used according to their strict meaning. Remember that Pascal's law applies only to confined fluids. Whenever a fluid is in motion in a hydraulic system, this law does not apply. This is because when the fluid is flowing it is not confined in the true sense of the word.

In figure 1-2 you see Pascal's law illustrated. When a force is applied to the piston in cylinder 1 it is transmitted to all portions of the confined fluid. If the applied force is equal to, let's say, 5 pounds per square inch, this pressure will press against every square inch of surface in cylinders 1, 2, and 3 and the tubing. It is applied at right angles to the surfaces. That is what Pascal's law says.

Now a change takes place. A lack of resistance causes either piston 2 or 3, or both, to move upward. This momentarily lowers the pressure in

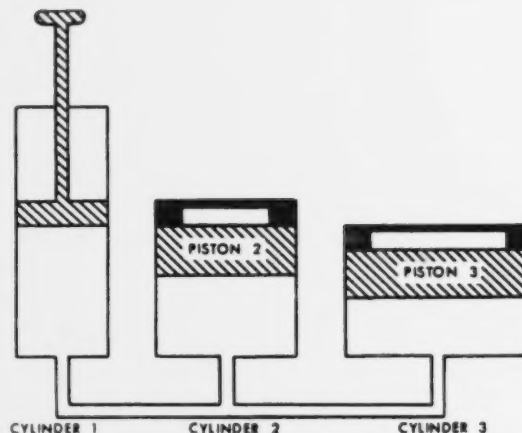


Figure 1-2. Application of Pascal's law.

cylinders 2 and 3, even though you are still applying a force of 5 pounds per square inch in cylinder 1. Obviously, this unbalanced condition cannot last. Fluid will flow from cylinder 1 to cylinders 2 and 3. This is because pistons 2 and 3 are not confining the fluid as long as it is moving upward. Hence, Pascal's law does not apply. When pistons 2 and 3 reach the end of their strokes, the fluid flow will have to stop. At this point the fluid is again confined and the pressure again equalizes. Now Pascal's law applies once more.

Now let's look at some pneumatic terms, and see how they relate to each other.

Exercises (200):

1. Define Boyle's gas law.
2. Define Charles's gas law.
3. Specify how Pascal's law applies to a confined liquid.
4. Specify how Pascal's law applies to a fluid in motion.

201. Given problems, determine the relationships between force, pressure, area and volume, area, length.

Pneumatic Terms. To understand hydraulic principles and their application to aircraft

pneudraulic systems, you must know the meaning and relationship of the following pneudraulic terms. Learn them as thoroughly as you can, because they are vital to your success as an aircraft pneudraulic mechanic.

Area. Area is the measurement of a surface. In this course we will express this measurement in square inches. In the aircraft pneudraulic system, for instance, we are concerned with the areas of piston heads. Knowing this area, we can figure the amount of force needed to actuate a mechanism. Should you wish to figure the square inch measurment of a piston for instance, you would use the formula $A = \pi \times R^2$. Pi is equal to 3.14 inches and instead of writing pi you can use the symbol π . For example if a piston head has a radius of 2 inches (radius is half the distance across a circle), use the formula $A = \pi \times R^2 = 3.14 \times 2^2 = 3.14 \times 4 = 12.56$ square inches.

Force. Force is the amount of push or pull exerted on an object. In this course we measure force in pounds. The force applied to a piston head is the total energy applied to the total area of the piston head.

Pressure. Pressure is the force applied to one part of the area, such as one square inch. In our work we measure pressure in pounds per square inch, or psi. The pressure acting on a piston head develops the force that moves or operates a mechanism.

Stroke. Stroke (length) is a measurement of distance expressed in inches. It represents the distance a piston moves in a cylinder.

Volume. Volume (displacement) is a measurement of quantity, expressed in cubic inches. It represents the amount of liquid contained in a reservoir or displaced by a pump or actuating cylinder. Should you wish to figure the cubic inch

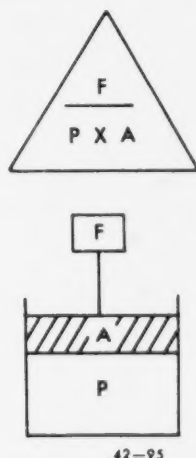


Figure 1-3. Relationship of force, area, and pressure.

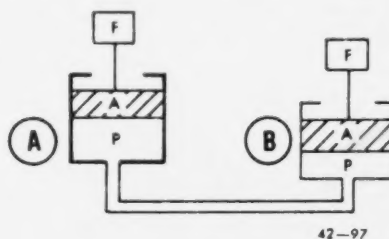


Figure 1-4. Applying the relationship of force, area, and pressure.

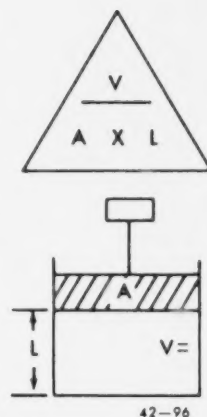


Figure 1-5. Relationship of volume, area, and length.

displacement (volume) of a cylinder, you can use the formula $V = \pi \times R^2 \times H$. For example, the volume of a cylinder 10 inches high (length) with a 2-inch radius is: $V = 3.14 \times 2^2 \times 10 = 3.14 \times 4 \times 10 = 125.6$ cubic inches.

Relationship of Force, Pressure, and Area. If we know any two of these factors, we can easily figure the third. To help in doing this, apply figure 1-3. Such a triangle is used in several areas of knowledge. To apply it, always multiply the two lower values to get the top value. Or divide the top value by the know lower value to get the other (unknown) lower value. For example, we know that force is the total of the pressures acting in each unit of area. Also, pressure is the total pounds of force divided up between the total square inches of area. To apply the triangle, if you know the values of A and P and want to get F, cover F and multiply A times P. This gives you the value of F. If you know the values of A and F and want P, cover P and divide F by A. If you have the values of P and F and need A, cover A and divide F by P.

Remember, F is always given in pounds, P in pounds per square inch, and A in square inches. Now, let's try some problems.

Example 1: A pressure of 50 pounds per square inch acts on a piston whose surface area is 5 square inches. What is the force acting on the piston? Use figure 1-3. Cover F and multiply P (50 psi) times A (5 square inches). The result is that F is a force of 250 pounds on the surface of the piston.

Example 2: A force of 480 pounds is exerted on a surface whose area is 12 square inches. What is the pressure on the surface? Use figure 1-3 again. Cover P ; divide 480 pounds (F) by 12 square inches (A). P will be a pressure of 40 pounds per square inch.

These problems seem simple enough, but not too many hydraulic systems work with only one cylinder. Let's look at a system that has two cylinders. Refer to figure 1-4. Cylinder A will act as the pump and the other as the actuating cylinder. If there is a force of 500 pounds pushing down on an area of 10 square inches, then the pressure will be 50 psi. When the 50 psi is applied to an area of 5 square inches in cylinder B , the resulting force will be 250 pounds. Notice that the pressure was the same throughout the problem.

Relationship of Volume, Area, and Length. Figure 1-5 shows the mathematical relationship between volume, area, and length of stroke. Once again a triangle is used to solve problems involving these three factors. For example, a piston of 8 square inches moves a distance of 10 inches within a cylinder. What is the volume of liquid displaced by the movement of the piston? Using the triangle in figure 1-5, we can easily calculate the volume. We cover V and multiply the two lower figures A and L . Eight square inches times 10 inches equals 80 cubic inches (V) which is the volume displaced (V).

Refer to figure 1-6 as we work a problem with volume, area, and pressure using two cylinders. Notice that cylinder A with a piston area of 10 square inches has been pushed down 4 inches. This then displaced 40 cubic inches of fluid from the cylinder. If this volume is applied to cylinder B

with a piston area of 5 square inches then the piston will move a total length of 8 inches. Notice that the volume was constant throughout the problem.

Exercises (201):

1. Calculate the area of a piston that is 2 inches across.
2. If a cylinder is 5 inches long and the piston has a radius of 3 inches, what is the displacement of this cylinder?

3. Find the area, pressure, and force for the following exercises.

a. Find F :

$$\begin{array}{rcl} \text{Area} & = & 4 \text{ sq in} \\ \text{Force} & = & \text{_____ lbs} \\ \text{Pressure} & = & 300 \text{ psi} \end{array}$$

b. Find A :

$$\begin{array}{rcl} \text{Area} & = & \text{_____ sq in} \\ \text{Force} & = & 500 \text{ lbs} \\ \text{Pressure} & = & 50 \text{ psi} \end{array}$$

c. Find P :

$$\begin{array}{rcl} \text{Area} & = & 3 \text{ sq in} \\ \text{Force} & = & 150 \text{ lbs} \\ \text{Pressure} & = & \text{_____ psi} \end{array}$$

4. Find the volume, pressure, and force for the following exercises.

a. Find V :

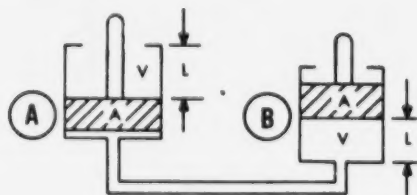
$$\begin{array}{rcl} \text{Volume} & = & \text{_____ cu in} \\ \text{Area} & = & 5 \text{ sq in} \\ \text{Length} & = & 1 \text{ in} \end{array}$$

b. Find L :

$$\begin{array}{rcl} \text{Volume} & = & 10 \text{ cu in} \\ \text{Area} & = & 2 \text{ sq in} \\ \text{Length} & = & \text{_____ in} \end{array}$$

c. Find A :

$$\begin{array}{rcl} \text{Volume} & = & 15 \text{ cu in} \\ \text{Area} & = & \text{_____ sq in} \\ \text{Length} & = & 3 \text{ in} \end{array}$$



42-99

Figure 1-6. Applying the relationship of volume, area, and length.

5. Using figure 1-6 find the volume, area, and length.

A

B

$$\begin{aligned} V &= 20 \text{ cu in} \\ A &= \text{sq. in.} \\ L &= 4 \text{ in} \end{aligned}$$

$$\begin{aligned} V &= \text{cu in} \\ A &= 10 \text{ sq in} \\ L &= \text{in} \end{aligned}$$

6. Using figure 1-4 find the force, area, and pressure.

A

B

$$\begin{aligned} F &= 800 \text{ lbs} \\ A &= \text{sq in} \\ P &= 400 \text{ psi} \end{aligned}$$

$$\begin{aligned} F &= 1600 \text{ lbs} \\ A &= \text{sq in} \\ P &= \text{psi} \end{aligned}$$

Mechanical Advantage (MA). You know that pulling a nail with the aid of a clawhammer, raising a car by means of a jack, or lifting an elephant with the aid of a chain hoist are all possible. What thing in common does each of these examples have? Each example, simply makes use of a mechanical device. The amount by which the applied effort is multiplied in the output of the device is the MA.

Of what importance is mechanical advantage in relation to the aircraft hydraulic system? The engineer in his mathematical calculations is primarily interested in mechanical advantage, for it enables him to accurately determine, among other things, the size of actuating cylinders and pistons, and the distance must have to operate a mechanism. Why is unit size important? Because space in an aircraft is limited, and operating units must be designed not only to be as strong as necessary, but to be as small and light as possible.

In figure 1-7, you see a simple illustration of MA. When the 50-pound force is applied to the small piston whose area is 2 inches square, the fluid

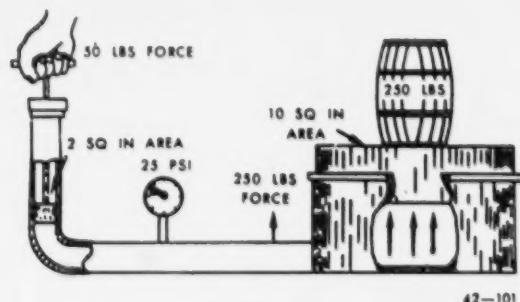


Figure 1-7. Mechanical advantage.

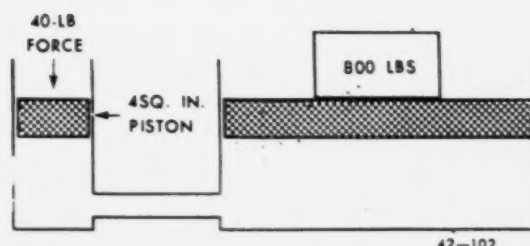


Figure 1-8. Applying mechanical advantage.

pressure becomes 25 psi, as indicated on the gage. Also notice that when the 25 psi acts on the 10 square inches of the large piston, the 250-pound barrel can be supported because a force of 250 pounds is applied to the bottom of the large piston. This gain in force (from 50 pounds to 250 pounds) is made by merely increasing piston area and not fluid pressure. This illustrates the concept of mechanical advantage used in many hydraulic devices.

MA is expressed as a ratio—in the above case it is 5:1 ratio. In hydraulics MA can be explained as the ratio between two pistons with regard to the previously discussed factors: area, force, and length (distance moved). The MA ratio serves as a useful shortcut for problems in hydraulics.

To illustrate, let us consider the two pistons shown in figure 1-8 and observe how the MA ratio serves this purpose. In figure 1-8 assume that we must raise the 800-pound weight by applying a 40-pound force to the 4-square-inch piston. Since MA is the ratio between the two values for each of three factors—force, area, and distance—we can rapidly calculate the MA and the values for the other factors. The mechanical advantage in this case can be obtained by dividing 800 pounds by 40 pounds; 20 is the result. Expressing the same idea in mathematical terms,

$$\text{Mechanical advantage} = \frac{\text{resistance}}{\text{effort}}$$

$$\text{or} \quad \text{MA} = \frac{R}{E}$$

Thus in the case above it would be

$$\text{MA} = \frac{800}{40} = 20$$

Hence the MA is expressed as the ratio 20:1. Multiplying 20 times 4 square inches (small piston area), we find the area of the large piston to be 80 square inches. Applying the MA ratio to the length and assuming that the large piston must move 10 inches, we find that the small piston must move 20 times 10, or 200 inches. Of course, it would not be

feasible for the small piston to move that far on a single stroke. Therefore, the small piston must move through a series of short repeated strokes, as in the case of a hydraulic jack or aircraft hydraulic system hand pump

Exercises (202):

1. If a force of 25 pounds is applied, what must be the mechanical advantage to achieve a force of 600 pounds?
2. If a force of 1000 pounds is applied, what must be the mechanical advantage to achieve a force of 3000 pounds?
3. If a force of 3000 pounds is applied, what would be the mechanical advantage to achieve a force of 45,000 pounds?

203. Indicate whether given statements correctly reflect the type of fluid flow and Bernoulli's principle.

Flow of Fluids. When the fluid is motionless in the system, there is no resistance to fluid flow. Only when the fluid is flowing do we have certain factors that affect the flow of fluid. Some of these are the tubing size, viscosity, and the particular units that are placed in the system. We will look at each of these in the following paragraphs.

Flow through tubing. Tubing is used to conduct the flow of pressurized fluid from one part of the pneumatic system to another. This fluid flow can either be laminar or turbulent. When you think of laminar flow of fluids, imagine the fluid as being in thin layers. The layers are parallel to the direction of flow with the first layer next to the wall of the tube. When the flow speed is low, the friction between each layer and the layer next to the tubing wall is low. In this condition, we say the flow is streamlined because one layer slides smoothly over the next layer or the wall. There is practically no resistance. A turbulent flow is a nonsmooth, whirling flow. Think of the little whirlpools formed at the edges of an oar when it moves through the water. Turbulence creates resistance and a loss of energy. A rise in temperature of the liquid is evidence of this loss of energy. Where does this resistance develop? First of all, between layer one and the tube wall, because the tube wall is stationary. As the velocity increases beyond a certain point, layer one suddenly becomes turbulent. Increases the velocity more, the turbulence will extend into layer two, then into layer three, and so forth. So, if you keep increasing the speed, you will find the area of turbulence increasing. To prevent this, the engineer must either reduce the required speed of the fluid, reduce the causes of friction, or enlarge the size of the tubing.

Viscosity. Viscosity is another factor that affects the resistance to fluid flow. Viscosity is a property of fluid that occurs primarily as a result of cohesion and interaction between the molecules of the fluid. Or, it can be simply described as the property of fluids, either liquid or gas, which causes them to resist flow. Viscosity varies with temperature. With liquids, the viscosity generally decreases with a rise in temperature. With gases the viscosity increases with increased temperature.

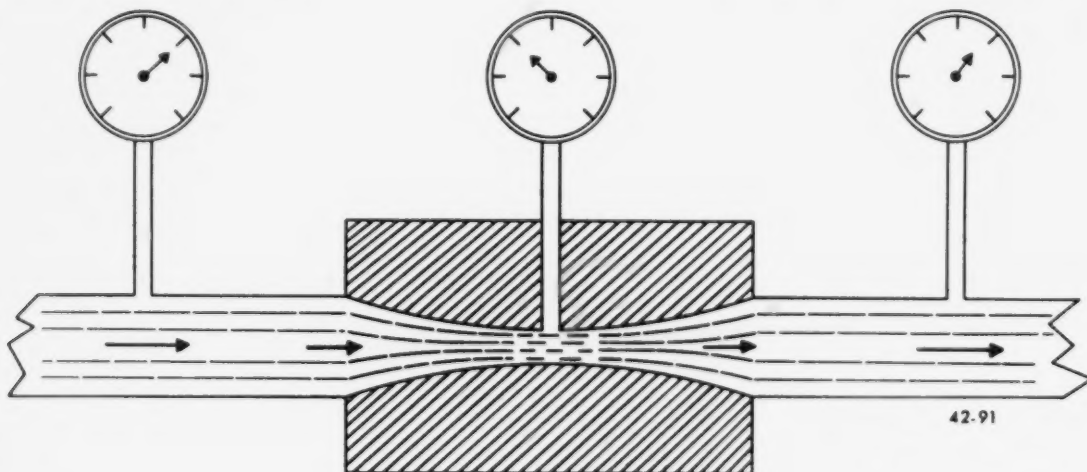


Figure 1-9. Fluid flow through a venturi.

Bernoulli's Principle. Daniel Bernoulli was a swiss mathematician who experimented with the flow of fluids. His principle states that: "The pressure of a fluid (liquid or gas) decreases at points where the velocity of the fluid increases." Figure 1-9 shows a venturi that can be used to illustrate Bernoulli's principle. A venturi is a tube whose cross section areas is gradually reduced to a smaller diameter. This narrow point is called the throat. Beyond the throat the tube again gradually enlarges to its original size. As you can see, there are no abrupt changes in cross section. Therefore, at operational velocities, a laminar liquid flow is maintained. The rate of flow must be the same at the gauges before and after the venturi throat. The gauges in the figure shows that the pressure is the same. Since the amount of liquid going through the throat is the same as through the larger tube, it has to be going faster. The center gauge shows that the pressure at the throat is less than in the tube.

This can be compared to men marching in a parade. Let's say you are a flight leader commanding the first flight of men in the parade. You are matching your men down a street 16 abreast. Suddenly, you come to a bridge only wide enough for 8 men to march abreast. You have to do something to keep the next flight behind you from either halting or slowing to a half-step. What will it be? You quickly form two flights and doubletime the men across the bridge. Immediately after passing over the bridge you reform to 16 abreast and resume normal step. If you didn't have the marchers resume the normal pace, they would run away from the rest of the formation.

Fluid flow through a venturi acts in the same way. As the fluid enters the venturi throat it speeds up and reaches maximum speed at the smallest cross section. As it passes out through the enlarging cross sections, it slows down to its original velocity.

Exercises (203):

Mark each statement true or false. If the statement is false, cross out the word or words that made it false and place in the words that will make the statement true.

- 1. In laminar flow the fluid flows through the tubing in thin layers.
- 2. Laminar flow is a nonsmooth whirling flow.
- 3. In a turbulent fluid flow, the turbulence creates resistance and a loss of energy.

- 4. If the speed of the fluid flow through the tubing is increased, the area of turbulence in the fluid will decrease.
- 5. Viscosity is the property of hydraulic fluid that causes it to resist flow.
- 6. Bernoulli's principle state's that "the pressure of a fluid will decrease at the point where the velocity of that fluid increases."
- 7. A venturi is a device that can be used in a hydraulic fluid line to maintain a turbulent flow.

204. From a given situation, calculate the amount of work expended and identify the type of energy described.

Energy. Energy is the ability to do work. Work is performed when a force acts on a body and moves it. The motion is the clue to the concept of work, and without it there is no work. Imagine some Egyptian slaves, thousands of years ago, struggling to move a 1000 pound block of stone for one of the pyramids. The slaves push and sweat, but the stone does not budge an inch; so, no work has been done. They rest a little, and return to the job and push harder than before. This time the stone moves 2 feet. They have done some work. The amount of work is equal to the force they exert times the distance the block was moved.

$$\text{Work} = \text{force} \times \text{distance} \text{ or } W = F \times D$$

thus

$$W = 1000 \text{ lbs} \times 2 \text{ ft} = 2000 \text{ ft-lbs.}$$

notice that the answer is foot-pounds (ft-lbs).

In our technical age, we need a unit of measurement for work. The unit of work commonly chosen is called a foot-pound. A footpound of work is the work required to move 1 pound a distance of 1 foot. The Egyptian slaves learned that work was an expenditure of energy that accomplished something. So, let's examine a few facts about energy.

Potential energy. Potential energy is energy at rest. A tightly stretched spring is ready to do work; so, it possesses energy. Compressed air has only to be released in order to do work; it, too, has energy. A lifted clock weight is able to make the clock run

because it has stored energy in its raised position. There are all examples of potential energy. A body has potential energy because of its position.

Kinetic energy. kinetic energy is energy in motion. A baseball flying through the air possesses kinetic energy. When you catch the ball, its kinetic energy warms your glove and stings your hand. A moving automobile, a moving stream of water, and the wind are also examples of kinetic energy. Any body in motion is able to do an amount of work equal to its kinetic energy. Conversely, if an amount of work is done to accelerate a body, the body requires an equal amount of kinetic energy.

Transformation of energy. Energy can be changed from one form into another in many different ways. Radiant energy of the sun strikes the earth; it is changed into heat energy and warms the earth. When sunlight falls on the leaves of plants, it is transformed into chemical energy. Electrical energy becomes sound energy in the telephone receiver, in the loudspeaker, and in bells. When gunpowder is fired, the chemical energy that was stored in it is released partly as heat and partly as mechanical energy in propelling a bullet.

Conservation of energy. The law of the conservation of energy states: energy can be neither created nor destroyed. No one has ever found a way to create energy out of nothing. No machine has been found that delivers more energy than is put into it. We can only use what is already here. A machine is not only helpless to create energy, but unable to destroy energy. A machine does not deliver all of the energy that is put into it. The energy that is not delivered is not destroyed. It is usually changed into heat energy. Fuel may be wasted by going up the flue in smoke; nevertheless, energy goes up with the smoke.

Exercises (204):

1. How much work is accomplished in lifting a 40-pound weight to a vertical height of 25 feet?
2. What type of energy is found in a hydraulic accumulator charged with hydraulic fluid and air pressure?
3. What type of energy is possessed by an aircraft moving down the runway?
4. To what type of energy is steam transformed into by a radiator?

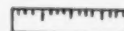
5. How much work is done in lifting a 100-pound sack of flour 4 feet in the air?
6. What type of energy is possessed by hydraulic fluid that flows through tubing?
7. What type of energy is possessed by pneumatic pressure that is held at a standstill in an air flask?

205. From given measurements calculate the equivalent values.

Systems of Measurement. The two most commonly used systems of measurement are the English system still in general use in the United States and the metric system, used in most European countries. This has lead to many complications, especially when a product is manufactured using the English system, and sold to a country using the metric system of measurement. This along with the fact that the metric system is easier than the English system, prompted the signing of the "Metric Conversion Act of 1975." This Act stated that "the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States." See figure 1-10 for English/metric conversions.

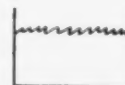
Length

- 1 inch = 2.54 centimeters
- 1 foot = .3048 meters
- 1 yard = .9144 meters
- 1 mile = 1.6093 kilometers



Volume

- 1 quart = .9464 liter
- 1 gallon = 3.7854 liter



Weight

- 1 ounce = 28.350 gram
- 1 pound = 453.59 gram



42-1834

Figure 1-10. English/metric conversions.

English measurement. Down through the ages, many units of measurement have become customary, and then faded into history as the people, or nations, died or fell to other conquering nations. In recent years, the mile, yard, foot, and inch have been customary in the English speaking nations to indicate distance. The ounce, pound and the ton, for units as weight and the pint, quart, gallon, etc., for volume. This seems quite simple, but let's face it, the only reason we're using the English system is that we're familiar with it. But honestly now, off the top of your head, how many pecks are in a bushel? How many feet are in a rod? Or, how many furlongs are in a mile? These are also units of measurement in the English system, but chances are you do not know them.

Metric system. The metric system is much simpler because there are three basic units—the liter, the meter, and the gram. The liter for volume, the meter for distance, and the gram for measuring weight. All of these are divisible by ten. Subunits are formed by using prefixes such as centi—for hundreds, and kilo—for thousands. As an example, 1 meter equals 100 centimeters and 1000 meters equals 1 kilometer. To get the feel of the new units, figure a meter as "roughly" one yard, a liter as "slightly larger" than a quart, and a kilogram as "little more" than two pounds.

Temperature. Two types of scales that are in general use for temperature measurement are the centigrade (Celsius) and the Fahrenheit. Figure 1-11 compares the two scales. Looking at the centigrade scale, you can see that 0° is the freezing point and 100° the boiling point of water. There are 100 divisions on the centigrade scale compared to 180 divisions on the Fahrenheit scale. Water freezes at the 32° point and boils at the 212° point on the Fahrenheit scale.

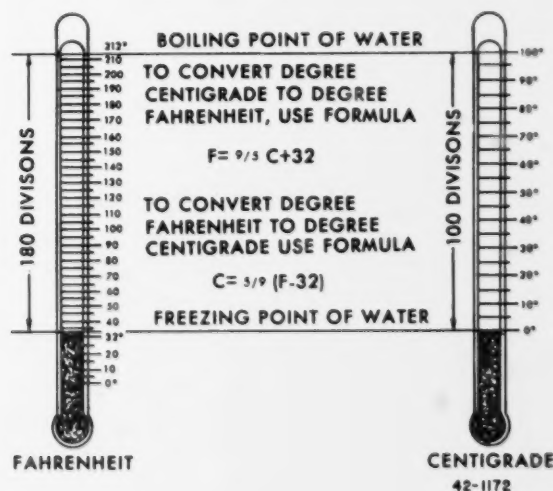


Figure 1-11. Temperature scales.

It may become necessary, at times, to convert from Fahrenheit to centigrade, or from centigrade to Fahrenheit. A simple formula for converting these temperatures can be used. When converting Fahrenheit temperatures to centigrade, subtract 32° from the Fahrenheit temperature and multiply the remainder by .556 (5/9). To change centigrade temperatures to Fahrenheit, multiply the centigrade temperature by 1.8 (9/5) and add 32°.

England, Australia, and Canada are already well advanced in implementing their plans for conversion to the metric system. The U.S. is preparing to join the rest of the world in a common system of weights and measures to allow the inch and the ounce to go the way of the dodo bird. This conversion won't be abrupt, in fact we could have a double system of measurement (English and metric) for at least a generation.

Exercises (205):

1. What would the approximate temperature be, using figure 1-11, in centigrade if the Fahrenheit temperature was 60°? Then using the formula, calculate the exact temperature.
2. You are tasked with servicing an accumulator. The TO specifies you should service it to a certain psi at 20° C. What is the equivalent Fahrenheit reading?
Use figure 1-10 to answer the following items.
3. If you were adjusting the length of a component and the TO wants you to adjust it to approximately 2 yards, what would the measurement be in meters?
4. A TO states that an actuator rod should travel 3 inches when bench checked. What is the equivalent measurement in centimeters?
5. A reservoir holds 7.56 liters of hydraulic fluid when completely serviced. How many gallons of fluid will it take to service the reservoir?

1-2. Electrical Fundamentals

During the early days of aircraft hydraulic systems, the need for understanding electricity was limited. At that time, we used engine-driven pumps,

hand pumps, and manually operated valves. Now, however, the modern aircraft hydraulic systems are almost entirely electrically controlled and hydraulically actuated. Remote units can be actuated almost instantly by movement of an electrical switch. The switch energizes a circuit that initiates the hydraulic operation of the unit. Thus, the system operator needs to know a little more than when to flip a certain switch.

This is true of the pneumatic mechanic. He must be able to locate and repair troubles in hydraulic systems. But, he must first determine if it is an electrical or a hydraulic failure. To do this, he must have at least a fundamental knowledge of electricity. This chapter will help you to develop your electrical knowledge of symbols, types of circuits, and the relationship of current, voltage, and resistance.

206. Indicate whether the given statements correctly describe the electron theory.

Matter. By definition, matter is "any substance that occupies space and has weight." There are three states of matter: (1) solids, (2) liquids, and (3) gases. Matter itself cannot be destroyed, but can be changed from one state to another by chemical or physical means. Water is a good example of matter changing from one state to another. In its normal state and at moderate temperatures it is a liquid. At high temperature it changes to a gaseous state known as steam, while at low temperature it becomes solid ice.

Elements and compounds. The three main states of matter can be broken down further and classified as "elements and compounds." There are over 100 elements and thousands of compounds. By combining elements we get compounds. By breaking compounds down, we get elements. For example, hydrogen is an element and oxygen is an element. By combining the two in proper proportions we get the compound water.

Molecules and atoms. A molecule is defined as the "smallest particle" of a compound that can still be identified as a compound. If you could see it, a water molecule would have two atoms of hydrogen and 1 atom of oxygen (H_2O).

The "atom" is the smallest part of an "element." Breaking down the atom would reveal the presents of three subatomic particles called the "electron, proton, and neutron." Figure 1-12 shows an example of an atom and its atomic structure. The center portion of the atom is called a "nucleus" and contains the protons and neutrons. The proton has a positive charge while the neutron is electrically neutral (has no charge).

The electron is a small body outside the nucleus and whirls around it in much the same manner as the planets orbit the sun. Electrons have a negative charge.

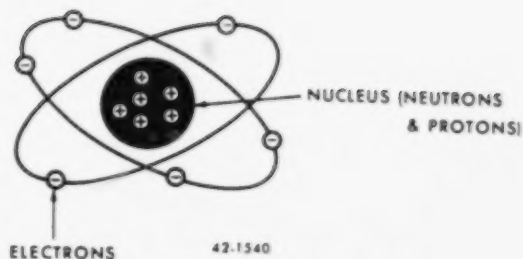


Figure 1-12. Atom.

Balanced and unbalanced atoms. Each atom must contain an equal number of electrons and protons to be "balanced" or electrically neutral. When an atom is balanced, the electrical charge of the protons and electrons cancel each other out. If, however, an atom lost an electron, there would not be enough negative charges to cancel the positive charge of the protons. This atom would be unbalanced and would have a positive charge.

If a balanced atom gained an additional electron, it would also be unbalanced. Now there are more negative charges than needed to balance the positive charges. This unbalanced atom would have a negative charge.

It follows then that for an atom to become unbalanced, it is considered to either have lost or gained electrons from its outer orbit. The outer orbit is the orbit that is the farthest from the nucleus. These electrons are not as tightly bound to the nucleus as those close to the nucleus.

Conductors and Insulators. In some substances the electrons in the outer orbit are easy to move from their orbit. Normally, they are moved from their orbit by the force of another electron entering their path of orbit. They may move from atom to atom in a haphazard manner. Electrons that are able to move in this manner are known as "free electrons." The atomic structure of a material will determine whether or not the material has many or few free electrons. (See figure 1-13.)

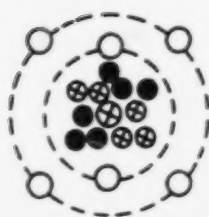
A "good conductor" is a material (such as copper) that has a large number of free electrons. The free electrons move from atom to atom in a haphazard manner. When this random movement is controlled so that the electrons move generally in the same direction, an electron flow results. This electron flow is called electric current. A good conductor permits free electrons to move through it and in doing so permits a current flow.

All metals are conductors of electricity to some extent, but some are much better conductors than others. Silver, copper, and aluminum are metals with many free electrons and, therefore, are good conductors. Copper is the most widely used. Conductors may be in the form of bars, tubes, or sheets, but the most common conductors are in the form of wire.

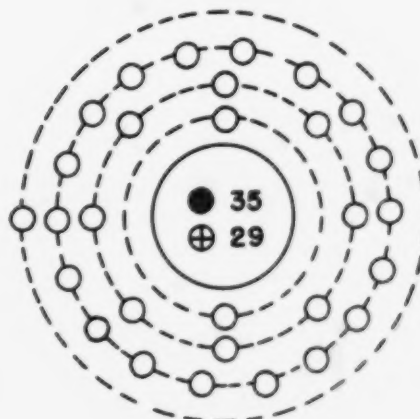
**HYDROGEN
ATOM**



**CARBON
ATOM**



COPPER ATOM



- ⊕ PROTONS
 ● NEUTRONS
 ○ PLANETARY ELECTRONS IN ORBITS

Figure 1-13. Balanced atom.

In order to make the wire easier to handle, and also less subject to changes in weather and other external conditions, it is often covered with some other material such as rubber, plastic, or varnish. These coverings are known as "insulators."

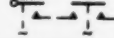
An insulator is a material, or combination of materials, the atomic structure of which opposes the movement of electrons from atom to atom. In other words, an insulator is a material that has few free electrons. No material is a perfect insulator but there are materials that are such poor conductors that for all practical purposes they are classed as insulators. Glass, dry wood, rubber, mica, and certain plastics are good insulators.

Remember when the random movement of free electrons is controlled, an electron flow, more commonly called electric current, results.

Exercises (206):

Mark each statement with a T if it is true or F if it is false. If the statement was false, cross out the word that made it false and write in the word(s) that would make it true.

- Matter can exist in three states: gas, solid and vapor.
- A compound is made by combining two or more elements.
- A molecule is the smallest particle of a compound that can still be identified as a compound.
- An atom is made up of protons, neutrons, and electrons.
- The nucleus of an atom contains neutrons and electrons.
- The proton has a negative charge, the neutron is neutral, and the electrons has a positive charge.
- A balanced atom has the same number of protons and electrons.
- An unbalanced atom with a positive charge has an excess of electrons.

	SINGLE POLE, SINGLE THROW
	SINGLE POLE, DOUBLE THROW
	DOUBLE POLE, SINGLE THROW
	DOUBLE POLE, DOUBLE THROW
	PUSHBUTTON, MAKE
	PUSHBUTTON, BREAK
	PUSHBUTTON, TWO-CIRCUIT
	PRESSURE SWITCHES (LEGEND ON DIAGRAM INDICATES THE OPERATION OF SWITCH)
SWITCHES	
	SOLENOID
	QUICK-DISCONNECT OR DRAW-OUT CONNECTOR
	WIRE CROSSING
	WIRE JUNCTION
	GROUND
	HORN
	BATTERY
	OHM
	CYCLE
	PHASE
	MECHANICAL LINKAGE
MISCELLANEOUS	
	PUSH-PULL TYPE
	PUSH TYPE
	SWITCH TYPE
	AUTOMATIC RESET TYPE
	FUSE OR CURRENT LIMITER
CIRCUIT BREAKERS	
	FIXED
	VARIABLE
RESISTORS	
	COIL
	POLARIZED RELAY
	NORMALLY OPEN CONTACT (MAKE)
	NORMALLY CLOSED CONTACT (BREAK)
	TRANSFER CONTACT
RELAYS	
	* INDICATES TYPE MOT - MOTOR GEN - GENERATOR DYNM - DYNAMOTOR MG - MOTOR GENERATOR
	REVERSIBLE MOTOR
	* INDICATES TYPE PI - POSITION INDICATOR OP - OIL PRESSURE INDICATOR XMTR - POSITION TRANSMITTER
ROTARY EQUIPMENT	
	ILLUMINATING
	NON-JEWELED INDICATOR OR WARNING LIGHT
	JEWELED INDICATOR WITH PUSH TO TEST CIRCUIT
	JEWELED INDICATOR OR WARNING LIGHT
* INDICATES COLOR A AMBER R RED B BLUE W WHITE C CLEAR Y YELLOW G GREEN O ORANGE NE NEON P PURPLE	
LAMPS	

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Figure 1-14. Electrical symbols.

9. A material that is a good conductor will have a large number of free electrons.
10. An insulator is a material that opposes the movement of electrons from atom to atom because it has few free electrons.

207. Using the chart of electrical component symbols, identify the symbols used in an electrical circuit, and indicate whether given statements correctly reflect the basic concerning current, electromotive force, and resistance.

Electrical Symbols. Every science has its own language—oral and written. The field of electricity is no different. We communicate electrically by means of wiring diagrams. A wiring diagram tells how a circuit is put together and how it operates. It shows all the wires or conductors used, the components, and how everything is interconnected. Wires are represented on the drawing by straight lines. Switches, solenoids, circuit breakers, etc., are not drawn out, but a symbol for each is used. Figure 1-14 shows these symbols, with their names.

A simple electrical circuit using some of these symbols is shown in figure 1-15. We will relate the components in this circuit to the components in a hydraulic system to show their similarity. Notice it consists of a battery (accumulator) that stores electrical pressure (if a generator is used, it would relate to a hydraulic pump). The two conductors on each side of the lamp would be like the pressure and return lines in a hydraulic system. The lamp would be like an actuator, the fuse like a relief valve, and the switch would act like a selector valve. There are many other units used in electrical circuit, so you should become familiar with the symbols used for electrical components.

Electrical Terms. Before delving too deeply into electrical circuits and symbols, we must understand some of the electrical terms that are used.

Electromotive force. The pressure that forces electrons through a conductor is called

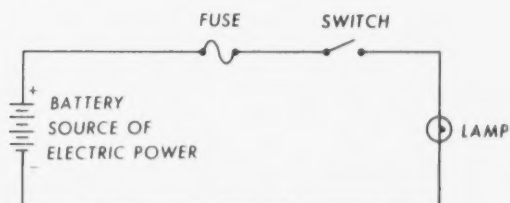


Figure 1-15. An electrical circuit.

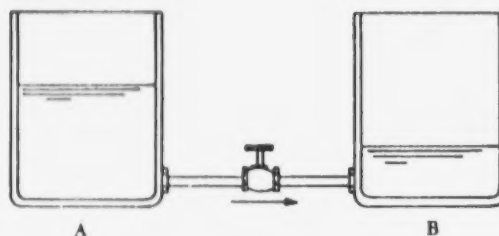


Figure 1-16. Difference in pressure.

electromotive force, voltage, or difference of potential. (All of these mean the same thing). Pressure in a hydraulic system is measured in pressure per square inch (psi), whereas the unit of measurement of electromotive force is called a volt and is measured by a voltmeter. The symbol for electromotive force (emf) in an electrical equation is E .

Current. Current is always measured by a rate of flow. As an example, the flow of fluid in a hydraulic system is measured by the quantity of fluid flowing through the pipe in a certain amount of time. We call this gallons per minute (gpm). Likewise the current on an electrical circuit is measured by the amount of electrons that flow through a wire in a second. This rate of flow (or intensity) is measured in amperes. The symbol for current is I .

Resistance. The opposition to the flow of current is called resistance. Resistance is supplied by a light bulb, solenoid, or conductor. The amount of resistance offered by a conductor depends upon: (1) the material of which the conductor is made—some metals conduct better than others; (2) the length of the conductor—resistance increases as the length increases; (3) the cross-sectional area—as the thickness of the conductor increases its resistance decreases; and (4) the temperature of the conductor—in most conductors the resistance increases as the temperature increases. The unit of measurement of resistance is called an ohm. The instrument by which resistance is measured is called an ohmmeter, and the symbol for resistance is R .

Now that we understand a little more about electromotive force, current, and resistance, let's apply it to a simple drawing as shown in figure 1-16.

Comparison of an Electrical Circuit to a Hydraulic Circuit. The flow of electric current can be compared to the flow of fluids between two interconnected tanks. Notice that the level of fluid in tank A is higher than the fluid level in tank B. Because there is more fluid in tank A than in tank B, the fluid is heavier and thus has more pressure (emf) than the fluid in tank B. The difference in pressure (emf) between the two tanks causes the fluid to flow (current) when the valve in the

interconnecting line between the tanks is opened. If the valve is opened all the way, the flow (current) will be fast because there isn't too much resistance. If the valve is closed slightly, the flow (current) will decrease as the resistance increases. When the fluid in the two tanks are at the same level, the flow of fluid (current) ceases because there is no longer a difference of pressure (emf).

AC and DC. There are two types of electrical power in use today. Alternating current (AC) is the type of electrical power in which current periodically reverses its direction. In direct current (DC), current flows only in one direction.

Exercises (207):

1. Specify the symbols for each of the following electrical units.

- a. Battery _____
- b. Ground _____
- c. Lamp _____
- d. Switch S.P.D.T. _____
- e. Fixed Resistor _____
- f. Solenoid _____
- g. Fuse _____
- h. Motor _____

2. Indicate by a T or F whether each of the following statements are true or false. If the statement is false tell what has made it false.

- a. ___ Electromotive force can also be called voltage.
- b. ___ Current is measured in amperes.

- c. ___ An electric motor can be considered as a resistance.
- d. ___ An ammeter is used to measure resistance.
- e. ___ The unit of measurement for electrical pressure is ohms.
- f. ___ The unit of measurement called the amp is actually the measurement of the number of electrons that are flowing in that electrical circuit.

208. Specify the relationship between voltage, current, and resistance; and using Ohm's law, find the unknown values in selected circuits.

Ohm's Law. While experimenting with electricity in the early 1800s, a German physicist, George Simon Ohm, discovered a definite relationship between voltage, current, and resistance. During his experiments Ohm found that:

- When voltage increased—current increased.
- When voltage decreased—current decreased.
- When resistance increased—current decreased.
- When resistance decreased—current increased.

From these findings, Ohm concluded that current in any electrical circuit is directly proportional to voltage, and inversely proportional to resistance. These discoveries led to more experiments and eventually became one of the fundamental laws used in analyzing electrical circuits. The law became known as Ohm's law and in modern language is stated as: The current (amperes) in a circuit is equal to the voltage (volts) divided by the resistance (ohms).

The same law written as an equation is:

$$\text{Current} = \frac{\text{voltage}}{\text{resistance}}$$

or

$$\text{Current} = \frac{\text{volts}}{\text{ohms}}$$

A common method of writing the law would be as a formula. For example,

$$I = \frac{E}{R}$$

It is important that you remember that Ohm's law applies to any part of a circuit as well as the entire circuit. Basic Ohm's law formulas are the simplest and most commonly used to find an unknown value (voltage, current, or resistance), when the values of the other two quantities are known.

Often, a memory aid is used to make the Ohm's law formulas more easily remembered. Remember the triangle formula we had earlier in this chapter for basic hydraulics ($F = AXP$)? We have a similar triangle for electricity, figure 1-17 illustrates the Ohm's law formula.

If you know any two of the three measurable properties of electricity, you can use the triangle to solve for an unknown third. To use the triangle, cover up the property of the circuit you want to find and the remaining equation will tell you how to get that property. Assume you want to find I,

cover up I and your resulting equation would be $\frac{E}{R}$ or E divided by R.

Now that you know how to find the correct formula, let's work on an actual problem. Assume that the battery shown in figure 1-18 is 6 volts and the resistance is 3 ohms. Using the triangle, determine the correct formula to find the current of the circuit. The formula you should use is:

$$I = \frac{E}{R} \quad (I = E \text{ divided by } R)$$

Therefore,

$$I = \frac{6}{3} = 2 \text{ amperes}$$

Using the same diagram, let's assume that the battery is 12 volts and the current is 2 amperes. What formula do you use, and what is the resistance? The correct formula is:

$$R = \frac{E}{I} \text{ or } R = \frac{12}{2} \text{ (12 divided by 2) } = 6 \text{ ohms}$$

So the resistance in the circuit is 6 ohms.

Exercises (208):

1. If a circuit contains 5 ohms of resistance and 50 volts is applied, what will the current flow be?
2. What is the voltage of a circuit that has 3 amperes of current flow and 4 ohms of resistance?
3. Ohm found that when voltage was decreased, current _____ and when resistance increased, current _____.

209. Use the correct formulas and solve problems in selected series circuits.

Series Circuits. A series circuit is the most simple circuit. In a series circuit there is only one path for current to flow, and electrical devices are connected



Figure 1-17. Ohm's law formula.

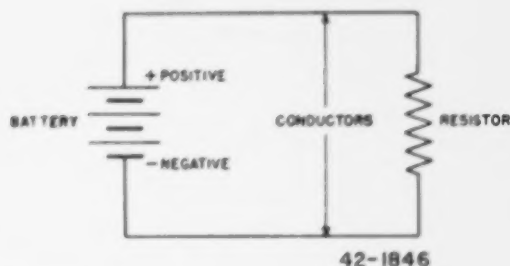


Figure 1-18. Simple series circuit.

end to end. The circuit shown in figure 1-19 is a simple series circuit. Current will flow from the negative terminal of the battery, through the resistor, and back to the positive side of the battery.

Voltage in a series circuit. Around 1850 a German physicist, Gustav Kirchhoff, elaborated on Ohm's law and developed his laws concerning voltage, current, and resistance. In simple everyday language, Kirchhoff's voltage law stated that in any closed circuit, the applied voltage is equal to the sum of the voltage drops around the circuit. In other words, by adding the voltage drops across each resistor we can determine the voltage of the source, or battery.

To determine the amount of voltage drop across any one resistor use the Ohm's law formula ($E = I \times R$) for that part of the circuit. Voltage drop is determined by multiplying the current (I) through the resistor by the resistance of the resistor (R).

Refer to figure 1-19 and let's figure the voltage drop across each resistor. An important point to remember is when you have more than one resistor in a circuit, the larger resistor will have the largest voltage drop. In our sample circuit, we know that the source (battery) voltage is 12 volts. The formula tells us that the voltage drop across resistor R_1 and R_2 will add up to 12 volts (the applied voltage).

By using Ohm's law, we can find the exact voltage drop across each resistor. First, however, you should know that the amperage of the circuit is 2 amps. How we arrived at this figure we will discuss in a moment. With this information and the formula for figuring voltage drops ($I \times R$), we can figure the voltage drop across R_1 (2-ohm resistor). We know what $I = 2$ amps and $R_1 = 2$ ohms, therefore, $2 \times 2 = 4$ volts dropped. Since there are only two resistors, R_2 must drop the remainder, or 8 volts. Remember, the voltage drops must equal (12 volts) the applied voltage. Let's check and see if R_2 does actually drop the remaining 8 volts. $I = 2$ amps $\times R_2 = 4$ ohms ($2 \times 4 = 8$).

Now, here is how we determined the circuit current was amperes.

Current in a series circuit. Kirchhoff's current law in a simple language states: In a series circuit, the same amount of current flowing into a junction must flow away from that junction. If ammeters were connected at several points in a series circuit, they would show how much current is flowing at various points in the circuit. All the ammeters would read the same amount of current. This is an important point to remember about a series circuit—current is the same at all points throughout the circuit. This may be expressed as $I_T = I_1 = I_2$. Use the following formula to find the current in a series circuit.

$$I = \frac{E \text{ (applied voltage)}}{R_T \text{ (sum of all the resistance)}}$$

Now, let's explain how we got 2 amps as the circuit current in the previous example. Refer again to figure 1-19. By adding the 2-ohm and 4-ohm resistances, we have a total resistance of 6 ohms. The formula tells us to divide the applied voltage 12 by the total resistance 6. Therefore, the circuit current equals 2 amperes.

Resistance in a series circuit. In a series circuit the total resistance is the sum of the individual resistances in the circuit. Expressed as a formula:

$$R_T = R_1 + R_2 + R_3$$

Did you notice as we explained the formula for voltage, current, and resistance that the total voltage was the sum of the voltage drops across the individual resistors? The current remained the same throughout the circuit. The total resistance was the sum of the individual resistors. These facts can be used in remembering what happens to voltage, current, and resistance in a series circuit.

Exercise (209):

1. Using figure 1-20, figure the unknown voltage, current, and resistance values.

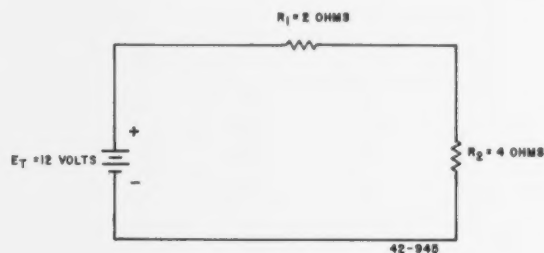


Figure 1-19. Series circuit.

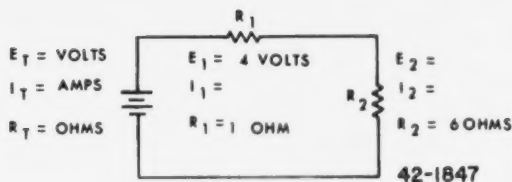


Figure 1-20. Objective 209, exercise 1.

210. Analyze parallel circuits and solve the unknown values of a selected parallel circuit problem.

Parallel Circuits. In addition to the series circuit, there is another type of basic current. It is known as a parallel circuit because it provides more than one path for current to flow. These separate paths are generally referred to as the "branches" or "legs" of the parallel circuit.

The introduction of additional paths for current flow results in a different set of rules of voltage, current, and resistance. Note the difference in the circuit as shown in figure 1-21.

Voltage. In a parallel circuit, the applied voltage is the same as the voltage drop across each element (the same voltage is applied across all legs of the circuit). Therefore, for a parallel circuit:

$$E_T = E_1 = E_2 = E_3, \text{ etc.}$$

Current. The total current in a parallel circuit is equal to the sum of the current flowing in the individual legs. Thus, for any parallel circuit:

$$I_T = I_1 + I_2 + I_3, \text{ etc.}$$

Resistance. In a parallel circuit, the total resistance is always less than the smallest resistance in the circuit. One method of determining the total resistance in a parallel circuit is by an indirect

method. First, let's refer to figure 1-21 and find the total amount of the circuit. If two values are known, the third value can be found by using Ohm's law. We know the voltage in each leg is 24 volts (as explained by the voltage law). We also know the value of each resistor; therefore, let's find the current (amperage) through each resistor. Then we will add up the current values to show total current in the circuit. To figure current of the first resistor (R_1) using ohm's law, you should be able to come up with 4 amps of current. Resistor R_2 has 2 amps and resistor R_3 has 2 amps. By adding the current of each resistor, we have a total current of 8 amps. Now, all we have to do is divide the applied voltage by this sum. Thus

$$R_T = \frac{E_T}{I_T} = \frac{24}{8} = 3 \text{ ohms}$$

Another method of determining the total resistance of this circuit is:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \text{ or } \frac{1}{R_T} = \frac{1}{6} + \frac{1}{12} + \frac{1}{12}$$

$$\frac{1}{R_T} = \frac{4}{12} \text{ or } R_T = 3 \text{ ohms}$$

When all resistors are of equal value—example, 9 ohms—use formula:

$$R_T = \frac{\text{value of one resistor}}{\text{number of resistors}} = \frac{9}{3} = 3 \text{ ohms}$$

In conclusion, the following observations should be made concerning parallel circuit operation. The addition of more resistors in a parallel circuit decreases the total circuit resistance. This is true regardless of how large or how small the resistors are. You must understand that this decrease in total resistance results in an increase of total current, if voltage remains the same. Therefore, if voltage remains the same, the total current can be increased by adding more parallel circuits.

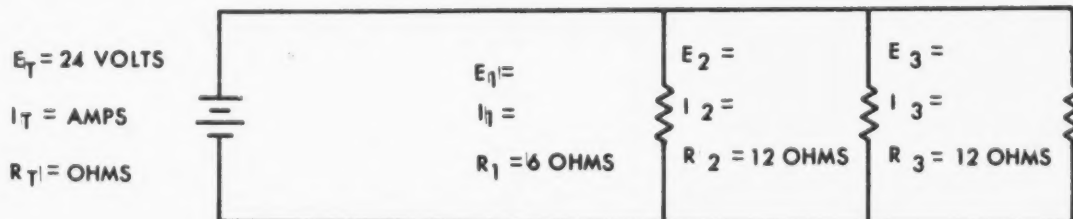


Figure 1-21. Parallel circuit.

Exercises (210):

1. What is the total resistance of a parallel circuit containing a 12-volt power source, and three resistors with values of 12, 4, and 6 ohms?
2. If voltage remained the same, what would be the effect on total circuit resistance if more resistors were added to a parallel circuit?
3. A parallel circuit has _____ path for current flow.
4. In a parallel circuit, _____ remains the same in all legs of the circuit.

211. Define a series-parallel circuit, and find unknown resistance values of a selected circuit.

Series-Parallel Circuit. Series-parallel circuits are those that have parallel resistances connected in series with other resistances. Any one of the parallel branches can also contain two or more resistances in series. Problems concerning series-parallel circuits can be solved by application of the rules already given for series and parallel circuits. To do this, the series-parallel circuit is first reduced to an equivalent series circuit. This procedure can be demonstrated by using the circuit shown in figure 1-22.

Referring to the circuit, you will find two 12-ohm resistors connected in parallel. This combination of resistors is in series with resistor R_3 . The first step in solving for total resistance is to find the combined resistance value of resistors

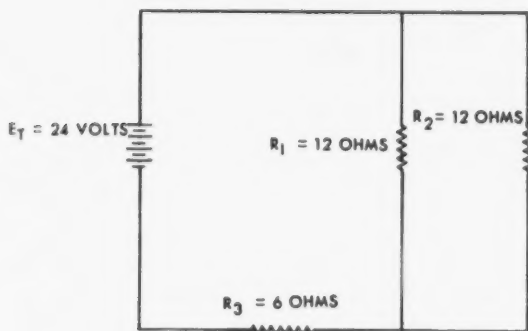


Figure 1-22. Series-parallel circuit.

R_1 and R_2 . Using the rule for resistors in parallel, you can determine this parallel sections resistance to be 6 ohms.

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{12 \times 12}{12 + 12} = \frac{144}{24} = 6$$

$$R_T = \frac{12}{2} = 6 \text{ ohms}$$

This simply means that there is really 6 ohms of resistance in the parallel portion of circuit. This resistance, you will notice, is in series with resistor R_3 . Adding the 6 ohms total resistance of R_1 and R_2 to the 6 ohms of resistor R_3 gives the total resistance of the entire circuit (12 ohms). By adding you are following the rule for finding total resistance in a series circuit. Now you can determine that the total current is 2 amperes.

All of the current passes through resistor R_3 and divides at the parallel section. One ampere of current flows through resistor R_1 , and one ampere flows through resistor R_2 . From the junction the current returning toward the positive terminal of the battery is once again 2 amperes.

These current values can be checked by applying Ohm's law to the parts of this circuit. It can be determined that the voltage loss across resistor R_3 is 12 volts. The remaining 12 volts applied to 12 ohms in each leg of the parallel section results in 1 ampere of current flow. You can see here the importance of completely understanding the rules for both series and parallel circuits in solving circuit problems of this type.

Exercises (211):

1. Define series-parallel circuits.
2. Find the total resistance of a series-parallel circuit having 2 parallel resistors (20 ohms each) in series with a 30-ohm resistor.
3. Find the total amps of a 24-volt series-parallel circuit having a parallel resistors (14 ohms each) in series with a 5-ohm resistor.

212. State the molecular theory and polarity of a magnet, then explain what is meant by an electromagnet.

The ancient Greeks are credited with the discovery of magnets in the town of Magnesia in

Asia Minor. The oriental cultures found that if a piece of magnetite were suspended, one particular end always pointed north. The Europeans used this principle as navigational aid and appropriately named the device a leading stone or lodestone.

Any substance that is capable of being magnetized or attracted by a magnet is commonly termed a "magnetic substance." Nonmagnetic substances are those not noticeably affected by a magnetic force.

Magnetic Theory. The molecular theory of magnets states that all magnetic substances are composed of tiny magnets that exhibit all the properties of magnets. When the material is unmagnetized, as shown in figure 1-23, A, all these tiny molecular magnets are disarranged and tend to cancel the effect of each other. However, when the unmagnetized material is brought near a magnet, the molecular magnets tend to align themselves, as shown in figure 1-23, B. The effects of the molecular magnets is concentrated and the material exhibits the characteristics of a magnet.

Magnetic Poles. When a magnet is suspended so that it is allowed to swing free in a horizontal plane, one end will always point north when the magnet comes to rest. It has been arbitrarily decided to call this north-seeking end of the magnet

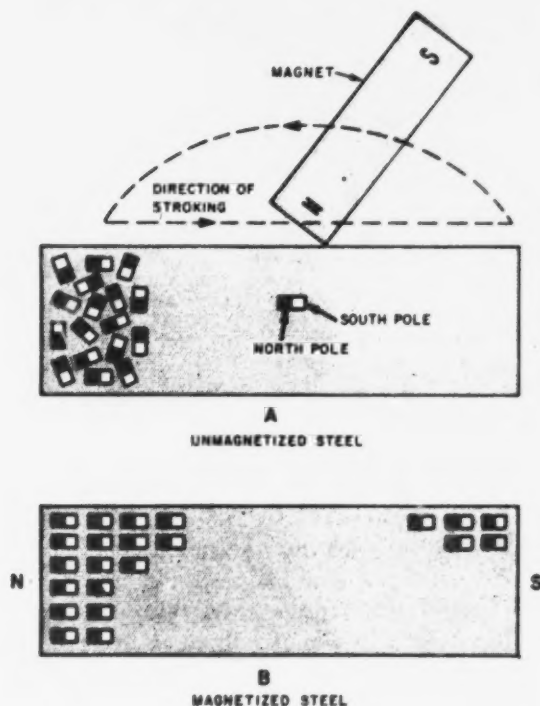
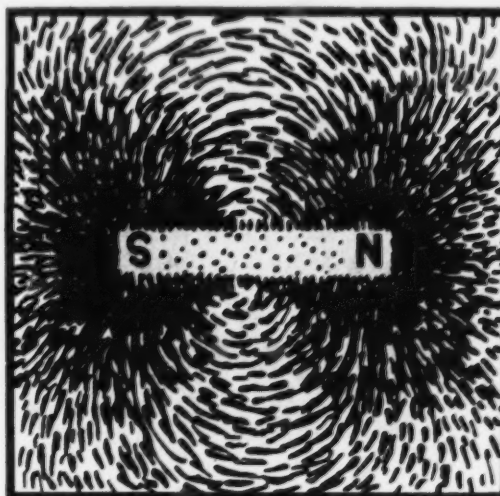


Figure 1-23. Molecular theory of magnets.



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Figure 1-24. Magnetic field of force.

the north pole. The opposite end is the south pole.

The law of attraction and repulsion of magnets can be demonstrated by placing another magnet near the suspended magnet. When the north poles are placed in close proximity, the suspended magnet will swing away from the stationary magnet. This indicates that like poles repel each other. Placing a south pole near the north pole of the suspended magnet causes the opposite effect. The north pole will then swing toward the stationary south pole. This action indicates that unlike poles attract, and like poles repel.

Magnetic Fields. The space surrounding a magnet contains invisible magnetic line of force. The area occupied by the lines of force outside the magnet is called the magnetic field. Although we cannot see magnetic lines of force, they are just as real as the force of gravity. Proof of this can be seen by placing a piece of paper over a bar magnet and sprinkling iron filings on the paper. When the paper is tapped lightly, the filing arrange themselves in a definite pattern, as shown in figure 1-24. The pattern made by the filings shows that a magnetic field does exist in an area surrounding the magnet. The lines of force themselves are sometimes called flux (flow lines). Figure 1-25 shows the direction of these magnetic lines of force. The lines leave the magnet at the north pole, travel outside the magnet, and reenter at the south pole. The flux lines then travel inside the magnet from the south pole to the north pole. In other words, magnetic lines of force (flux lines) travel externally, from north to south, and internally, south to north.

Magnetic Field About a Straight Wire. By an experiment we can prove the existence of a magnetic field surrounding a conductor carrying

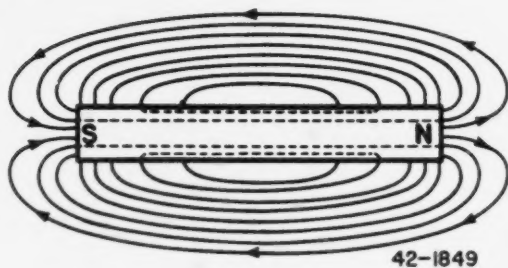


Figure 1-25. Flux pattern of a bar magnet.

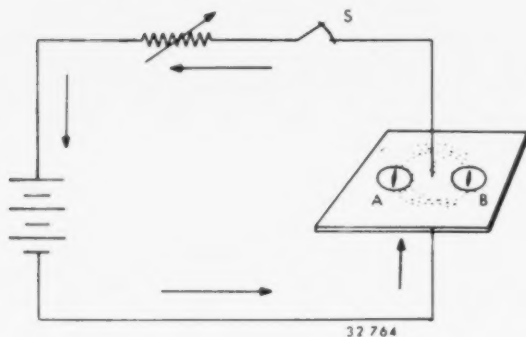


Figure 1-26. Magnetic field around a straight wire.

DC. Figure 1-26 illustrates the experimental procedure used. Note that a straight piece of wire is passed through a hole in a piece of glass and connected to a source of DC through a rheostat and switch. By sprinkling iron filings over the glass, then tapping it gently, the filings will arrange themselves in circles about the wire. If two magnetic compasses are placed on the glass, the compass needles will point in the direction of the magnetic lines of force as shown in figure 1-26. The north pole of each compass indicates the direction of the magnetic lines of force. In this experiment the magnetic lines of force will travel in a counterclockwise direction. The result of this experiment shows that a magnetic field does exist about a current carrying a conductor, and that the field also has direction. If the battery is reversed, the direction of the current in the circuit is reversed. The direction of both compass needles will then change by 180° . Thus, a change in the direction of current produces a change in the direction of the magnetic field. The important point to remember with respect to the above experiment is that whenever an electric current is flowing, a magnetic field exists.

Magnetic Field About a Coil of Wire. Let's take a straight wire and form it into a loop as in figure 1-27. The magnetic lines around the wire will be as

shown. With current flowing in it, the loop of wire acts like a short bar magnet. The face of the loop that the lines enter is the south pole, and the face that they leave is the north pole.

If you wind several loops to form a coil or solenoid as shown in figure 1-28, a more powerful magnetic field will be created. Inside the coil, the lines are concentrated to form a power field, while outside the coil they are spread out.

A coil like that of figure 1-28 with current flowing in it is the equivalent to a bar magnet. Its magnetic field has the same shape as the field of a bar magnet, and it obeys the same laws of magnetism that a bar magnet obeys. That is, the unlike poles of two coils attract each other and the like poles repel. If the coil is free to rotate in a horizontal plane, and is placed in a magnetic field, it will rotate, as will a compass needle to take position such that the lines inside the coil are parallel to the lines of the field.

Electromagnets. Very strong magnets can be made by winding a coil around a piece of iron or steel (such constructed magnets are called

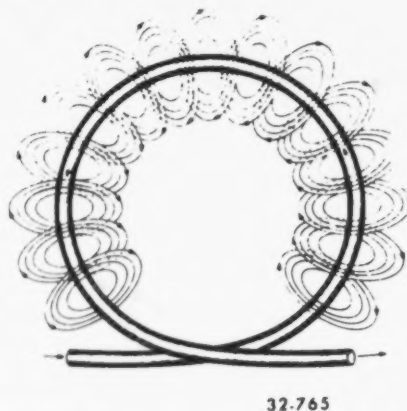


Figure 1-27. Magnetic field around a coiled wire.

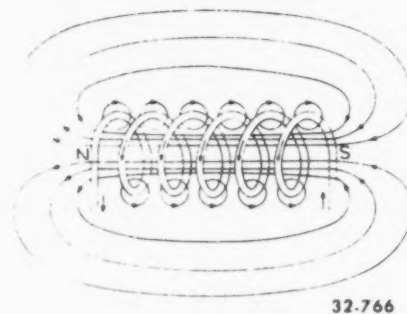


Figure 1-28. Magnet field about several coils of wire.

electromagnets). The reluctance (opposition to magnetic lines of force) of iron is so much lower than air that the same electric current in the coil sets up thousands of times more lines of magnetism than with an air core. Of course, the larger the electric current, the more lines that will be set up in the core and thus, the more powerful will be the magnetic field. Also, the more turns of wire wrapped around the core, the stronger the field. A field of a given strength can be produced by using many turns of wire carrying a small current, or by using few turns of wire carrying a larger current. Thus, an electric current of 2 amperes flowing in a coil of 5000 turns will produce the same number of lines as a current of 20 amperes flowing in a coil of 500 turns. The product of the number of turns in a coil, and the amperes flowing in the coil, is called the ampere-turns of the coil. Two coils with the same number of ampere-turns will, if their cores are identical, produce magnetic fields of the same strength. The same product of amperes and turns gives the same effect, no matter what the separate values of current and turns may be.

Now let's place a bar of iron or soft steel in the magnetic field of a coil as shown in figure 1-29. The bar will become magnetized. Since the bar has less reluctance than air, magnetic lines flow through it. If the field is strong enough, the characteristic of magnetic lines to shorten themselves causes the bar to be pulled into the coil until its center is near the center of the coil where the field is most intense.

If you place the bar on the other side of the coil, it will also be drawn into the coil. The bar becomes magnetized by the field of the coil in such a way as to be attracted into the coil.

Exercises (212):

1. State the molecular theory of magnets.
2. Define the word "flux," when used in association with a magnet.

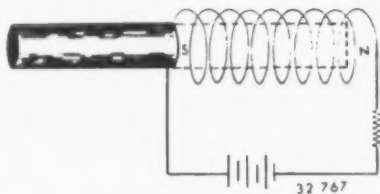


Figure 1-29. Action of an electromagnet.

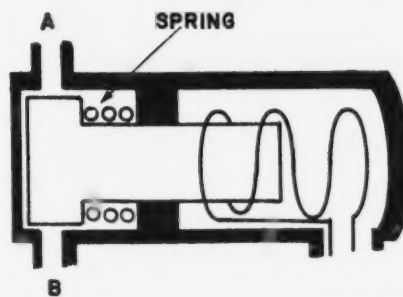


Figure 1-30. Simple electrical shutoff valve.

3. Which of the following statements is true?
 - a. Like poles repel—unlike poles attract.
 - b. Like poles attract—unlike poles repel.
4. Magnetic lines of force leave the magnetic _____ pole, travel outside the magnet, and reenter at the _____ pole.
5. Explain what is meant by the word "electromagnet."

213. Explain the use and operation of electromagnetism in valves, electrical relays, and motors.

Electrical Valves. Many of today's hydraulic valves are operated or controlled by electromagnetism as are relays and certain types of meters. For us, the most important use of this action is in the hydraulic valve. Hydraulic valves are made in many different sizes and shapes and used for various purposes. The valve shown in figure 1-30 is a simple shutoff valve. The coil (solenoid) is wrapped around the spool, which when energized creates a magnetic field. Energizing the coil draws in the spool, which compresses the spring. This allows the fluid entering port A to exit through port B. As long as the coil is energized the valve will maintain in this position. Once the coil is deenergized, the spring forces the spool to block off port A, thus, stopping the flow of fluid from port B. This is just a simple explanation of the use of electromagnetism in a hydraulic valve.

Electromagnetic Relays. A relay consists essentially of a coil with an iron core and movable iron bar. When current flows in the coil, electromagnetism pulls the movable bar toward the core. The movement of the bar opens or closes a circuit.

Figure 1-31 shows a basic relay and relay circuit. The relay itself consists of five main parts: core, coil, armature, contacts, and spring. When switch S is closed, current flows through the coil and causes

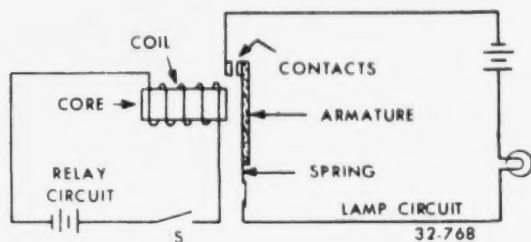


Figure 1-31. Basic relay.

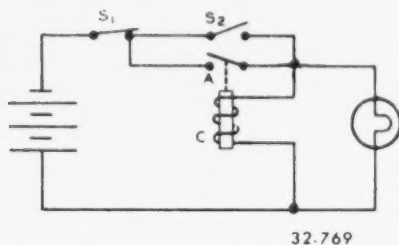


Figure 1-32. Holding relay.

a strong magnetic field to be set up around the coil. This magnetic field pulls the armature toward the core of the coil, causing the contact points to close; this completes a path for current in the lamp circuit. Closing the relay circuit controls the lamp circuit, and the lamp glows. When switch S is opened, the field about the electromagnet collapses, the spring pulls the armature contacts apart and the lamp circuit opens. All relays have a spring arrangement to open the load circuit when the switch is opened.

Another relay circuit is shown in figure 1-32. The closing of switch S2 will permit current to flow in coil C. The contact arm (which contains iron) will be attracted toward the upper end of the electromagnet, thus, closing the circuit at A. This permits a complete path for current in coil C and in the lamp circuit. The lamp will glow. Now opening the switch S2 will not open the coil or lamp circuit. In order to do this, switch S1 must be opened. This is the action of a holding relay.

Electrical Motor. Electrical motors provide a mechanical output (torque) from an electrical input. As an example, when you plug an electrical fan into the wall socket, the fan is taking the electrical input and changing it into a mechanical output (fan blade rotates). Figure 1-33 shows a simple illustration of an electrical motor. Notice that a coil of wire is placed between two fixed magnets. This coil of wire is called the armature.

Attached to the armature are the commutator segments. These segments automatically change the polarity of the coil as it rotates, within the magnetic

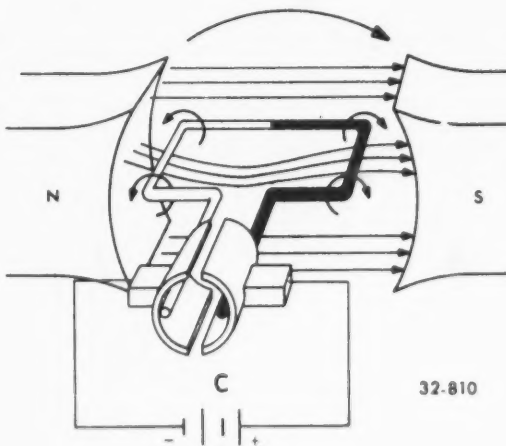
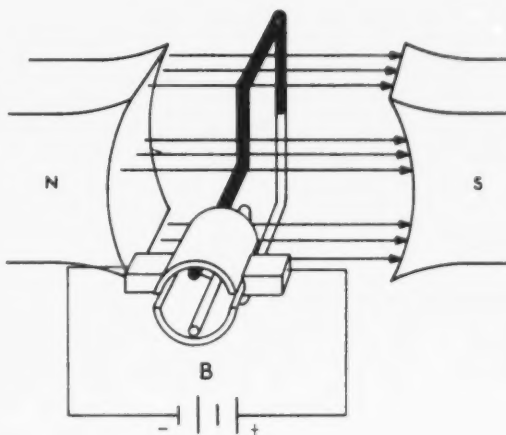
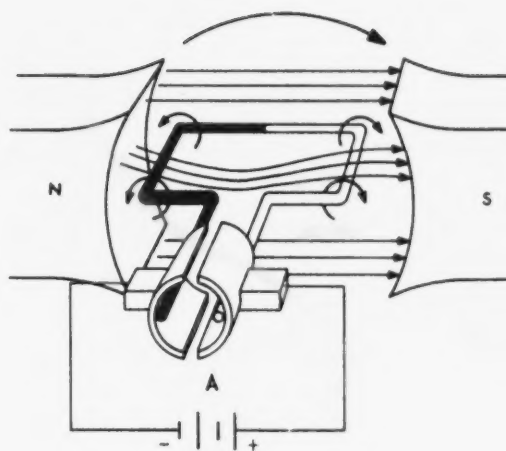


Figure 1-33. Simple electric motor.

field of the fixed magnets. In constant contact with the commutator segments are the brushes. Notice that one brush is connected to the positive side of the battery while the other is attached to the negative side. Now follow along as we discuss the operation of an electrical motor. In figure 1-33, A, current from the battery flows through the coil, and creates a magnetic field. The dark portion becomes the north pole while the white portion of the coil is the south pole. The north pole of the coil is repelled by the north pole, but is attracted by the south pole of the fixed magnet. The same goes for the south pole of the coil. This interaction of the magnetic fields causes the coil (armature) to rotate. As the armature rotates the commutator segments rotate, whereas the brushes and the fixed magnets are stationary. When the coil reaches the neutral plane (figure 1-33, B, insulating material between the commutator segments prevent the brushes from making a complete circuit from the battery to the coil, thus, the magnetic field for the coil collapses. The magnetic field rapidly builds back up to maximum, however, as soon as momentum moves the coil past the neutral plane, and the brushes make contact with the opposite commutator segment. Note in figure 1-33, C, that current flow through the coil now enters the white portion of the coil. The white portion now becomes the north pole while the black portion becomes the south pole.

This action causes the armature to continue rotating in a clockwise direction.

Now if you can picture a shaft attached to the armature, you can see how it can be used to turn a pump or operate a hydraulic valve.

Exercises (213):

1. In the valve shown in figure 1-30, how is the spool positioned to let fluid flow from port A to port B?
2. What is the magnetic field in a relay used for?
3. How is the armature of a motor rotated?
4. What automatically changes the polarity of the armature as it rotates within the magnetic field of the fixed magnets?

Pneudraulic Systems Materials

SELDOM A DAY passes that you do not use hydraulics in some form. Each time you turn a faucet to get some water, you apply the principle of hydraulics. The opening of the faucet starts confined fluids to move, possibly for miles. Each time you turn the steering wheel of an automobile—a model that has power steering—or every time you apply the brakes you are using hydraulics. This is the same form of hydraulics used to help pilots fly our most modern aircraft.

In this chapter we are concerned with the type of fluids, lubricants, and seals that will be used in a hydraulic system. Different types of seals require different types of hydraulic fluids and lubricants. Serious damage to the aircraft and injuries to the crew could be the result of using the wrong hydraulic fluid or lubricant. We shall also discuss the cleansers that are used to clean the hydraulic components and the safeguards involved in their uses.

Also in this chapter tubing and hoses will be covered. No hydraulic system will operate satisfactorily unless the tubing and hose used can withstand the pressure in the system.

Finally we shall discuss hardware and safetying devices. The loss of small bolt nuts and the improper use of safetying devices have been known to cause aircraft accidents.

2-1. Fluids, Lubricants, and Seals

The proper operation and correct maintenance of a hydraulic system can depend on the correct use of fluids, lubricants, and seals. As a pneudraulic systems mechanic you should be able to identify the various types of hydraulic fluids and lubricants that are used. Used with the various types of hydraulic fluid are seals. Some seals are designed to work only in specific equipment; therefore, you should know the type of seal that will work with each type of hydraulic fluid.

Also, in this section we will cover cleaning agents. You will use a cleaning agent any time a hydraulic unit is disassembled and overhauled.

214. Specify the characteristics and use of various types of hydraulic fluids.

Hydraulic Fluids. In order to operate efficiently in aircraft systems, hydraulic fluid must have certain properties and characteristics. It must have the ability to flow freely at extremely low temperatures, as well as at high temperatures. It must be noncorrosive to metals and not deteriorate the packings and gaskets used in the systems. Hydraulic fluid must have good lubricating qualities, low toxicity, high flashpoint, and be made from products that are readily available and of reasonable price. As you work on different aircraft and ground-powered equipment, you will come into contact with many different types of hydraulic fluids. Hydraulic fluids are classified according to their base (basic) ingredient. Two of the types with their base material and specification number are listed below.

Type	Base	Specification Number
Mineral	Petroleum	MIL-H-5606
Synthetic	Phosphate Ester	Skydrol 500

Petroleum base hydraulic fluid (MIL-H-5606). This type of fluid is used in most aircraft and missile hydraulic systems. This fluid has certain additives that are to improve viscosity and temperature qualities. It also contains oxidation inhibitors and antiwear agents. A red dye is added to the fluid for identification purposes only, and has no affect on the quality of the fluid. It is available in one grade, with an operating range of -65 (-53.9° C) to 275° F (135° C). This wide operating range is an advantage because the fluid will perform adequately in summer and winter temperatures. The seals required with the petroleum-base fluid may be of synthetic rubber, leather, teflon or metal composition. One disadvantage of MIL-H-5606 is that it has a relatively low flashpoint (it has a flashpoint of 200° F). MIL-H-5606 has been known to catch fire especially if it is spraying out under pressure from a pinhole in a tube onto a hot spot of an engine. It is generally supplied in 1 quart and 1 gallon containers. The container will have several numbers

and codes to identify its contents. A sample of these numbers and codes is shown below.

Specification Number	NATO Symbol	Military Symbol	Nomenclature
MIL-H-5606	H-515	OHA	Hydraulic Fluid Petroleum Base

The specification number covers the general requirements for manufacture and procurement. Such as heat range and color. The NATO symbol is a code number assigned to a product after it has been classified as standardized between two or more countries. No product is allocated more than one NATO symbol, and a number once assigned is never used for any other product. The military symbol is used to designate a particular item used by the military.

Petroleum base preservative hydraulic fluid MIL-H-6083. This is a preservative-type fluid used in the preservation of hydraulic systems and components. This type of fluid contains additive materials similar to those found in MIL-H-5606 hydraulic fluid, with the addition of corrosion inhibitors. It is intended for use as a preservative oil, and is also used as a testing and flushing oil for some hydraulic components. It should not be used in operational aircraft hydraulic systems because of its increased viscosity at low temperatures. Units that have been stored with this type of fluid must be drained to the drip point prior to installation in the aircraft. Landing gear shock struts that contain small amounts of MIL-H-6083 need not be completely drained, since the increase in viscosity is not harmful to shock strut performance.

Phosphate ester base hydraulic fluid (Skydrol 500). Skydrol 500 is presently being used in Medivac and VIP aircraft because of its fire resistance qualities. It has a flashpoint of 360° F.

Exercises (214):

1. List at least five characteristics a hydraulic fluid must have in order for it to perform efficiently.
2. What is the purpose of the red dye that was added to MIL-H-5606?
3. How is hydraulic fluid MIL-H-6083 used?
4. Why is Skydrol 500 used in Medivac and VIP aircraft?

5. What type of hydraulic fluid is used in most missile and aircraft systems?
6. When will a NATO code number be added to a product?

215. Specify the use of cleaning agents and the hazards associated with their use.

Cleaning Solvents. A hydraulic unit, when it is disassembled and overhauled, should always be cleaned with a suitable solvent. Solvents are liquids that dissolve other substances, much like a sugar cube will be dissolved when it is placed in a glass of water. At no time should maintenance personnel clean aircraft parts or equipment with gasoline, jet fuel, or any other unauthorized solvents. You should always consult the appropriate technical order for the correct procedure and cleaning agent to use. Cleaning solvents are used to remove dirt, grit, foreign matter, or sludge that may be lodged on the aircraft and component parts. There are a great number of different solvents, but as a pneudraulic specialist you will use basically two types.

P-D-680 solvent, drycleaning. This material is a petroleum distillate commonly used in aircraft cleaning. It is furnished as type I and type II. Type I material, commonly known as Stoddard solvent is flammable with a flashpoint slightly above 105° F. Type II is also flammable, but has a higher flashpoint of 138° F and is preferred over type I, for this reason. It may be applied by sponge, brush, spray or cotton wiping cloths. Once the part is cleaned it should be completely dried with compressed air or lint-free cloth. P-D-680 leaves a slight residue on the surface of the part after it dries that may interfere with the adhesion of paints. Some of the symptoms you might receive if overexposed to P-D-680 would be a headache, dizziness, vomiting, and sleepiness. Always make sure there is adequate ventilation when using it, and avoid prolonged breathing of its vapors. It can also cause dermatitis (inflammation of the skin) by removing the natural oils of the skin. You can minimize skin contact by wearing rubber gloves.

Trichloroethylene. We know this cleaning agent by its application in the ultrasonic filter cleaner. This material is practically nonflammable at ordinary temperatures. This solvent is a clear colorless liquid with a characteristic odor (similar to chloroform). This solvent is very volatile (evaporates rapidly) and should be stored in tightly sealed containers when not in use. Some of the symptoms you might display while working with trichloroethylene are dizziness, loss of appetite,

sleeplessness, headaches, fatigue, vomiting, and dermatitis. Here again, you should use the proper protective equipment, face shield (goggles), aprons, and gloves, and most of all have the proper ventilation. Without proper ventilation you inhale large doses of solvent vapors which go directly into the bloodstream. They could, over long periods of time, cause damage to the liver and other vital organs of the body. Trichloroethylene vapor concentrations around degreasers frequently exceed the allowable standards of health and safety. For this reason, studies are now in progress to find a substitute cleaning solvent that performs similar to trichloroethylene but is less dangerous. One of these recommended for use is trichloromethane (methyl chloroform).

In addition to the breathing hazard associated with solvents, they also present varying degrees of fire and explosive hazards. It is considered that solvent cleaners having a flashpoint greater than 105° F are relatively safe. The flashpoint is the temperature at which the first flash from the material is seen, as an open flame is passed back and forth over a sample of the flammable liquid that is being heated in a cup.

Another hazard associated with solvents, and to a certain extent with all cleaning materials, is the affect on the surface of the unit or material being cleaned. Some solvents will deteriorate rubber, plastics, and even certain paints. This is so important that it must always be taken into consideration when selecting cleaning materials. It may do a good job in removing dirt, grease, and oil, but may also damage the object being cleaned. For further information on cleaning solvents, refer to TO 1-1-1.

Abrasive Cleaning Materials. Whenever an aircraft component has a nick, dent, scratch or some other imperfection, you should use the proper abrasive cleaning or polishing papers. If you don't, you could completely damage the part beyond repair. For example, the grain structure of carborundum (silicon carbide) papers are so sharp and hard that individual grains will penetrate and bury themselves in the surface of the material being cleaned. Emery paper or crocus cloth used on aluminum or magnesium can cause serious corrosion of the metal by the iron oxide particles of the paper being imbedded in the metal. This could eventually cause unnecessary wear of the component, especially, if it was on a moving part with every close tolerances. One abrasive paper which can be used on most surfaces is aluminum oxide paper (300 grit or finer). It is available in several forms and sizes. Remember, follow tech order procedures and you can't go wrong.

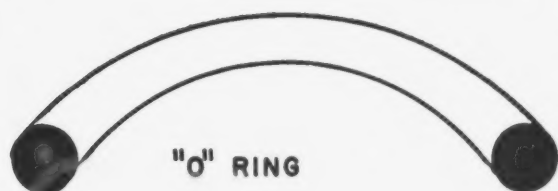
Exercises (215):

1. What are some of the symptoms of over exposure to P-D-680?

2. Why are solvents used?
3. Which solvent is used in the ultrasonic filter cleaner?
4. What are some of the symptoms from over exposure to trichloroethylene?
5. At what flashpoint are solvents considered relatively safe?
6. What are abrasive cleaning materials used for?
7. What kind of abrasive paper can be used on most surfaces?
8. What would be the result if crocus cloth was used on aluminum?

216. Indicate whether given statements correctly relate basic facts pertaining to commonly used seals and their installation.

Seal Shapes and Types. Seals are used to minimize or prevent internal and external leakage between two objects. There are so many types of seals, some method of classifying them needed to be established. Since the shape of a seal is its major distinguishing feature, this was the method chosen. IF you were to look at the cross section of a seal as shown in figure 2-1, you can see this more clearly. Notice that the O-ring is circular in shape, the D-ring looks like a D, and the T-ring looks like an upside down T. Although this isn't the only way of classifying a seal, it is the simplest. Seals used in hydraulic and pneumatic systems are of two general types: dynamic and static. The dynamic seals are used to provide a seal between two moving parts of a unit. The static seal is used as a seal between two stationary parts. Most of the dynamic and static seals used on today's aircraft are manufactured in the form of O-rings and are called packings. However, conditions will arise when special nonstandard seals will have to be made for specific uses on the aircraft. (See figure 2-2.)



"O" RING



"T" RING



"D" RING



"V" RING

42-1836

Figure 2-1. Shapes of seals.



42-360

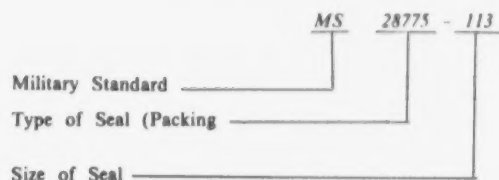
Figure 2-2. Nonstandard seals.

Material of Construction. Seals are made from several different types of materials. The material depends on the use of the seal and the type of fluid it will come in contact with. The seals used in petroleum-base hydraulic fluid (MIL-H-5606) are made from synthetic rubber (nitrile).

Seals in Skydrol 500 fluid systems are made from ethylene-propylene. Because most of our present day aircraft use petroleum-base fluid MIL-H-5606, we will stick with the seals associated with it.

Advances in aircraft design make it necessary to develop O-ring seals out of compounds that could meet the ever changing aircraft conditions. Hydraulic O-rings were originally established under AN (Air Force—Navy) specification numbers (6227, 6230, and 6290) for use in MIL-H-5606 fluid at operating temperatures ranging from -65° to 160° F. (See figure 2-3.) When aircraft designs raised the operating temperatures, newer compounds were developed under MS (Military Standard) specifications with an operating range of -65° to 275° F. These newer compounds are used to manufacture such O-ring seals as the MS28775 and MS28778 (packings). The MS28775 is replacing the AN6227 and AN6230, and the MS28778 O-ring is replacing the AN6290. However, O-ring replacement should only be accomplished by part number as specified in technical order.

O-Ring Part Number. The part number of a standard o-ring seal is shown below.



If you can't find the seals part number in the technical order, its size may help you determine its part number. The size of an O-ring seal may be determined by measuring the seals width (W), the inside diameter (ID), or the outside diameter (OD). Figure 2-4 shows the various dimensions that can be measured. If two are known, the third can easily

NUMBER	NAME	APPLICATION	SYSTEM	REMARKS
O-RING				
AN6227	Packing, O-ring	Static and dynamic	Hyd, pneu	General use -65°F to +160°F
AN6230	Gasket, O-ring	Static only	Hyd, pneu	General use -65°F to +160°F
MS28775	Packing, O-ring	Static and dynamic	Hyd (MIL-H- 5606), pneu	General use -65°F to +275°F
O-RINGS FOR FLARED TUBE FITTINGS				
MS28778	Packing, flared tube	Flared tube bosses	Hyd, pneu	Replaces AN6290
NONEXTRUSION RINGS				
MS9058	Ring	Teflon backup for use with MS28778 O- ring gaskets in flared tube bosses	All	Replaces AN6291
MS28774	Retainer, single turn	Teflon backup for use with AN6227, AN 6230, MS28775	All	---
MS28782	Retainer, double turn	Teflon backup for use with AN6227 and MS28775	All	In process of re- placing AN6246
MS28783	Ring, double turn	Teflon backup for use with AN6230 and MS28775	All	Replaces AN6244

42-1526

Figure 2-3. Application of O-ring seals and backup rings.

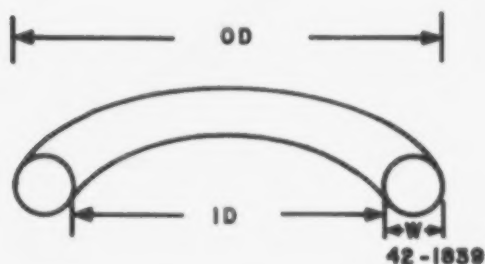


Figure 2-4. Seal dimensions.

be determined. For example, the outside diameter can be found if the width and inside diameter are known. Twice the width plus the inside diameter will equal the outside diameter. Once you have taken the measurements of the seal you will have to cross-reference it in the supply catalogs.

Installation of Seals. Generally, the O-ring seal requires no adjustment when it is installed. Figure 2-5 shows a typical O-ring installation. However, you must observe a few precautions at installation, or early failure will result. First of all, check to see that the seal is the right size. Inspect it visually for cuts, nicks, or flaws, and discard it if any defects are noted. Technical orders will specify what special lubricant is applied. When installing, use extreme care to prevent scratching or cutting the seal on threads or sharp corners. Also, make certain that it is not installed twisted; otherwise, it will not function correctly. To facilitate removing an O-ring seal, a special tool may be made, as shown in figure 2-6.

This tool can be made of soft iron, aluminum, or brass rod. Be sure that the edges are flattened and free of burrs. Some seals may be removed by squeezing the seal between the thumb and forefinger, forcing the O-ring out of the groove. Then the entire seal is removed.

Storage of Seals. Packings and gaskets should be stored in a dark, cool, dry place; they should be kept away from excessive heat, exposure to strong air currents, dampness, and dirt. Do not expose them to electric motors or other equipment that

give off heat and ozone. Any packing should not remain in storage for a period that exceeds its cure

Exercises (216):

Indicate whether the following statements are true or false. If false, explain why it is false.

- 1. Seals are classified according to their shape.
- 2. Dynamic seals provide a seal between two stationary parts.
- 3. The seals for MIL-H-5606 are made of synthetic rubber.
- 4. In the O-ring part number MS 28775-113 the type of seal is indicated by the number 113.
- 5. In installing a seal you should just check to see if the seal is the right size.
- 6. Packings can be stored for 3 years only.
- 7. The heat range of an MS packing is -65° F to 160° F.
- 8. The material a seal is made of depends on the use of the seal and the type of fluid it will come in contact with.

217. Using the information on an O-ring seal package, identify part number, nomenclature, and the cure date expiration date.

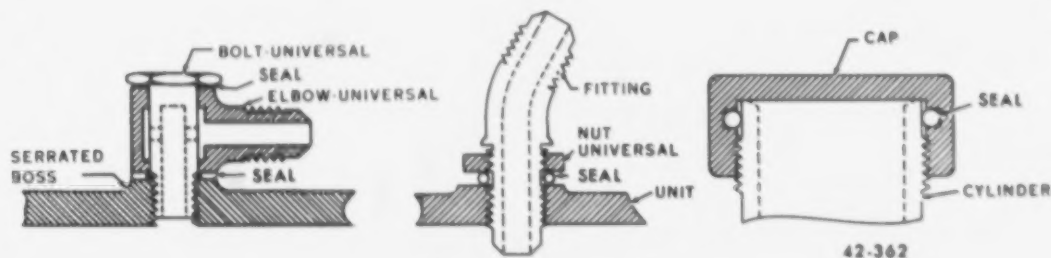


Figure 2-5. Seal installation.

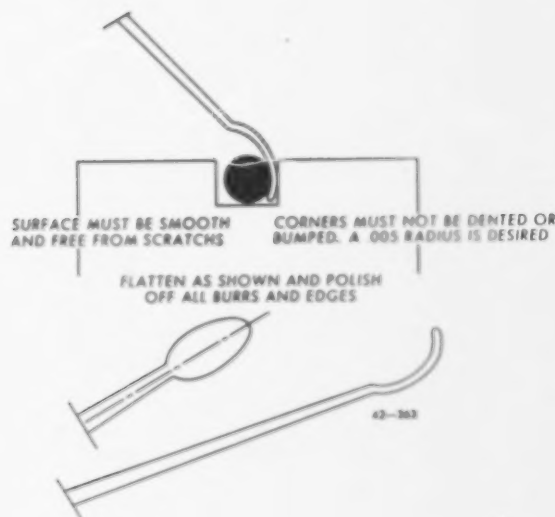


Figure 2-6. Seal removal tool.

O-Ring Identification. O-rings are manufactured according to Military specifications and are identified from the technical information printed on the O-ring package. (See figure 2-7.) The size of O-rings and their composition cannot be positively identified by visual examination without the use of special equipment. As an example the seals used in the hydraulic system containing petroleum fluid (MIL-H-5606) uses synthetic rubber seals, while the seals used in Skydrol 500 fluid uses seals made from butyl rubber (ethylene-propylene). Both look identical as far as outward appearance goes, but if you were to place a synthetic rubber seal (nitrile) in a hydraulic system using Skydrol 500 fluid it would cause the seal to swell. For this reason, O-ring seals are made available in individually sealed packages, labeled with all the necessary data pertaining to that seal. You must go by the data given in the applicable technical order pertaining to nomenclature, part number, and stock number for the correct seal to use. NOTE: Colored dots, dashes, and stripes or combinations of dots and dashes on the surface of the O-ring seal are no longer used for identification.

Figure 2-7 shows the information printed on O-ring packages essential to determine the intended use, qualifications, and age limitations. The manufacturer's cure date is one of the more important printed items listed on the package. For example, if the cure date was 2Q75, this indicates that the O-ring was manufactured during the second quarter (April, May, or June) of 1975. Most O-ring age limitations are determined by this cure date. The age limitation of O-rings is based on the fact that the material deteriorates with age. The manufacture determines the seal's service life. If the

manufacture estimates that the seal will not deteriorate over a 5-year period, then he sets the cure date expiration date at 5 years from the date of manufacture. In this case it would be 2Q80. Sometimes the manufacturer prints the expiration date directly on the seal package as shown in figure 2-7.

Exercises (217):

Using the information found on the seal package in figure 2-7, answer the following questions.

1. What is the part number of the seal?
2. When was the seal manufactured?
3. What is the cure date expiration date?
4. State the nomenclature.

218. Cite the principle cause of O-ring damage, and indicate the type of lubricant to use when repairing a component in the pneudraulic system.

Cause of O-Ring Damage. One of the principle sources of O-ring damage is friction (the seal

5330-00-579-7916
FSCM 95272 MFR. P/N: A-115
PACKING, PREFORMED "O" RING
1 EACH (P/N: MS28775-115)
DSA500-75-M-5942
A-7/75
SPEC. MIL-P-25732B
STILMAN SEAL DIV
SARGENT INDUSTRIES
MFR. COMP: SR832-75
BATCH NO: 395
TYPE I SHELF LIFE ITEM
DATE CURED: 1Q75
EXPIRES: 1Q80

42-1812

Figure 2-7. O-ring seal package.

sticking to the metal). O-rings will fail very rapidly if allowed to run dry, especially on piston rod seals of actuating cylinders. This could cause the seal to roll and even be cut as the piston rod moves in and out of the actuator. The defense against friction of course is to insure proper lubrication.

Lubrication of Hydraulic System Seals. Because hydraulic fluid has lubrication qualities of its own, the seals in the system do not need additional lubrication. Exception: a light film of hydraulic fluid is recommended though, to lubricate seals during installation and assembly of hydraulic components. In some instances the technical order recommends using a grease (petrolatum) specification VV-P-236. This grease should be applied very lightly to the seals, not packed into the O-ring seal groove. However, the technical order should be the deciding factor on determining the type of lubricant to use.

Lubrication of Pneumatic Systems Seals. Lubrication of pneumatic seals is more difficult to control than is hydraulic seal lubrication. Pressurized air from the system does not lubricate the seals as the hydraulic fluid does. Actually, the air dries out the seals and any lubricant that may

be on them. To prevent this from happening grease Military Spec. MIL-G-4343 is recommended for use in pneumatic systems. It has qualities that are better suited for pneumatic systems, and should not be substituted unless specifically stated in the TO. As an example, it will not harden and jam solenoids of valves and orifices when it gets cold. Applying the grease to a pneumatic unit is different than applying grease to a hydraulic component. For example, on a pneumatic actuating cylinder, the O-ring seals and seal grooves should be packed with a pneumatic grease, and the felt wiper should be thoroughly impregnated with the grease. After the unit is assembled, it should be operated through several complete cycles to spread the grease over all working surfaces. Remember this may be the only lubrication this unit may receive for years to come, so be sure to grease it properly.

Exercises (218):

1. If during disassembly of an actuating cylinder that was leaking excessively, you found an O-ring seal cut, what is probably wrong?

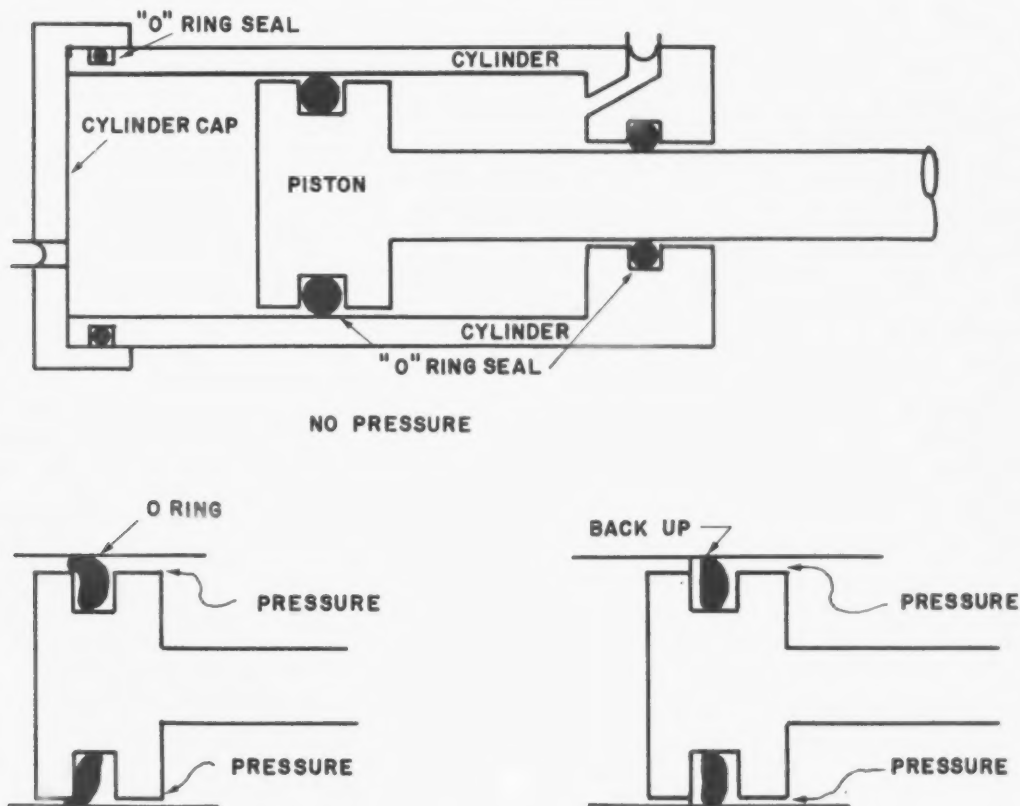


Figure 2-8. O-ring seal with nonextrusion device.

2. When repairing an item in the hydraulic system, what type of lubricant should be used, unless specifically specified in the TO?
3. When applying a lubricant to a unit in the pneumatic system, why should you apply the lubricant liberally?
4. What type of lubricant is recommended for pneumatic systems?
5. What can be considered the principle cause of O-ring damage?

219. From a given situation, indicate if a backup ring is required, and if it is installed properly in relation to an O-ring seal.

Backup ring. The O-ring seal, when used alone, is limited to systems having a maximum operating pressure of 1500 psi or less. This is particularly true when it is used on parts that move in relation to each other. If the seal is subjected to a high pressure (3000 psi), it may be forced out of the O-ring groove and become pinched. The lower left-hand illustration in figure 2-8 shows a set of O-ring seals being pinched because of high pressure. This condition may be prevented by using nonextrusion devices, better known as backup rings. If pressure is exerted on the seal in one direction only, you place the backup ring away from the pressure as shown in the lower right-hand illustration of figure 2-8. If pressure is applied in alternate directions, one backup ring must be placed on each side of the O-ring seal.

Two types of materials are commonly used as backup rings; leather and Teflon. The older types of backup rings are made of leather, and although they work fine as a nonextrusion device, they have one major disadvantage, corrosion. When moisture comes in contact with the leather backup it causes a chemical reaction to take place. Because of this you will find that Teflon backup rings (MS28774, MS28782, MS28783 and MS9058) are replacing many of the leather backups (AN6244, AN6246 and AN6291). Even though leather backup rings are being replaced by Teflon, they are still being used, and for this reason we will discuss their use. The leather backup ring has two distinct sides; the hair (smooth) side and the flesh (rough) side. The hair side will be dyed various colors (yellow, blue, black

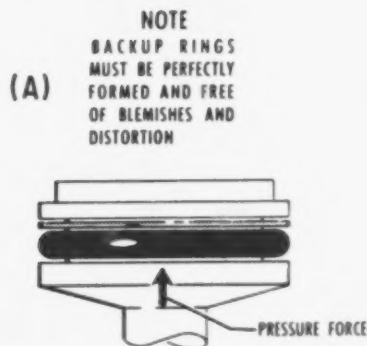
etc.) and it will always be placed next to the O-ring seal. Teflon backups are made from a fluorocarbon-resin, in both single and double spiral. The Teflon backups are split for easier installation. The point at which the split ends join together is called the scarf. When two backup rings, figure 2-9, (B), are installed, the split scarfed ends must be staggered. Also the split scarfed ends must not overlap, as shown in figure 2-9, (C), instead they should join together smoothly. Whenever a Teflon backup is too small, it will have a buckled appearance as shown in the lower illustration of figure 2-9, (C). Some advantages of Teflon backup rings are; they do not deteriorate with age, are unaffected by other fluids, and have a high temperature range. The Teflon backup rings are a milky white in color.

Exercises (219):

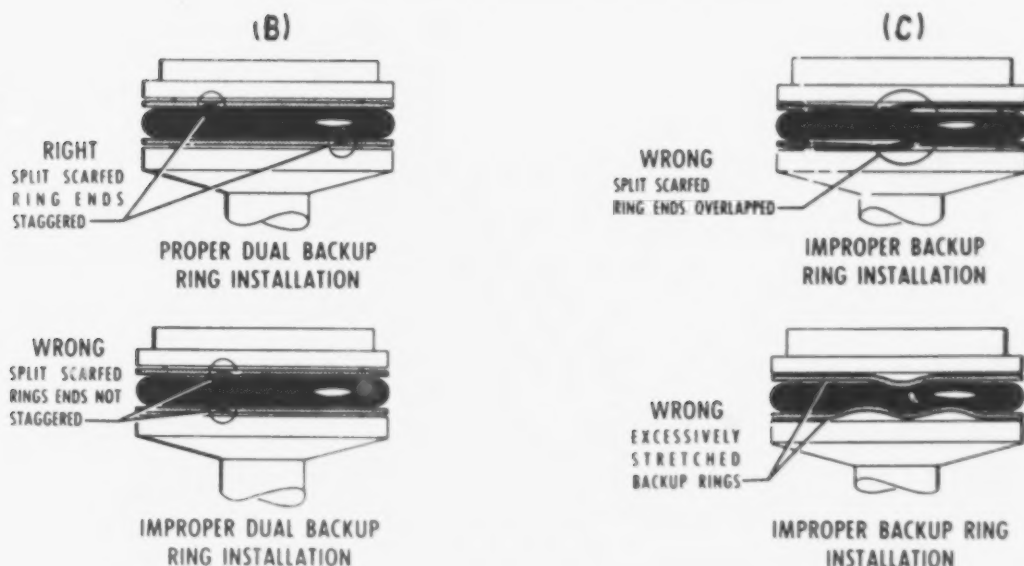
1. *Situation:* Hydraulic system pressure or 1100 psi. You have disassembled an actuating cylinder and now must reassemble it. Should you place a backup ring on either side of the piston O-ring seal? Explain your answer.
2. *Situation:* A single actuating cylinder is used in a 3000 psi hydraulic system. Should a backup ring be used and if so where?
3. *Situation:* Two backup rings have been installed on either side of an O-ring seal on a piston. The split scarfed edges of the two backup rings that were installed overlap. Have they been installed correctly? Explain your answer.
4. *Situation:* You are going to install a leather backup ring next to an O-ring seal on a system that has 3000 psi. The pressure will be exerted on the piston in one direction only. How would you install this backup ring?

220. Specify how leakage is prevented around drive shafts of rotating pneumatic components.

Shaft Seals. We have talked about seals used on actuating cylinder to prevent leakage. The actuating cylinder moves in and out (linear), but what do we use to prevent leakage on components that rotate. Many people know that when a pump leaks around the shaft, that it probably is the shaft seal that is



PROPER SINGLE BACKUP RING INSTALLATION



42-1828

Figure 2-9. Backup ring installation.

leaking. Not too many people though know how the shaft seal works. Most shaft seals on pumps (figure 2-10) have two flat surfaces that rotate against each other. Usually one flat surface is made from a soft material such as bronze or carbon and is called the sealing ring. The other flat surface is made from stainless steel and is called the mating ring. The mating ring rotates with the drive shaft.

Although all makes of shaft seals differ in design, they perform the same function, which is to seal a moving part—the shaft. The shaft seal must limit the leakage of fluid trying to escape, but not stop it

altogether. This is because the shaft seal acts like a bearing and must be lubricated like one. The lubricant comes from the slight leakage of fluid past the two mating surfaces.

In figure 2-10 notice that the sealing ring can move back and forth on the drive shaft. The O-ring seal will prevent leakage around the seal, while the spring forces the mating ring against the sealing ring. The spring compensates for the wear of the sealing ring by forcing the mating ring against the sealing ring. It also insures a positive seal when the shaft is not rotating. Never scratch or damage the two mating surfaces, because they will leak.

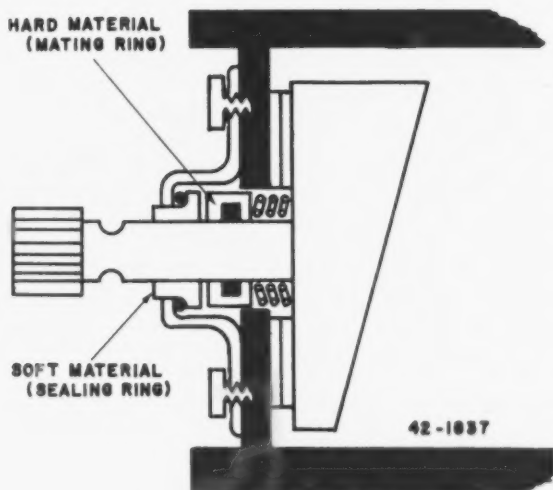


Figure 2-10. Pump shaft seal.

Exercises (220):

1. If you found fluid on the shaft seal of a hydraulic pump, should the pump be replaced? Explain your answer.
2. What does the spring behind the mating ring do?
3. Name the two basic components of a pump shaft seal.
4. What is the sealing ring usually made of?
5. Which component rotates with the drive shaft?

2-2. Tubing and Hose

Modern day aircraft have hundreds of feet of fluid lines running throughout their wings and fuselage. The pneumatic specialist is responsible for inspecting and maintaining some of these fluid lines. This frequently involves the fabrication and replacement of hose assemblies and in some cases tubing itself. This section is devoted to the maintenance of both rigid tubing and flexible hose.

221. Indicate whether given statements correctly reflect facts pertaining to the material, size, and installation of tubing assemblies; correct the incorrect statements.

Tube Assemblies. Two of the most common types of tube assemblies used on today's aircraft are the flared tube and the MS flareless tube. These tube assemblies consists of three basic parts; the B-nut, sleeve, and the tubing itself.

Tube assemblies are made up mainly of aluminum alloy or stainless steel tubing. In hydraulic systems, 5052-0 aluminum alloy tubing (Spec. WW-T-700/4) is used for reduced pressures (1500 psi maximum) and return lines. For pressures up to 3000 psi, aluminum alloy 6061 (Spec MIL-T-7081) is used. Steel tubing is also used in high-pressure hydraulic systems (3000 psi), especially in areas of intense heat, in exposed areas of wheel wells and in areas of extreme vibration. In later model aircraft, titanium is gradually coming into use because of its light weight and strength, but it will not be covered at this time.

The tubing used in the manufacture of rigid tubing assemblies is sized by outside diameter (OD) and wall thickness. Outside diameter sizes are in sixteenth-inch increments. (See figure 2-11.) Thus, a number 6 tubing is 6/16 or 3/8 inch; number 8 tubing is 8/16 or 1/2; etc. Wall thickness is specified in thousandths of an inch, such as, 0.028, 0.035 etc.

Tubing Assembly Manufacture. It is the prime job of the sheet metal shop to manufacture tubing according to the size and shape required. You, as a pneumatic specialist, however, should know what must be done prior to installing it on an aircraft. First of all, metal filings should be removed, then the tube assembly should be proof pressure tested. Things you should look for will be discussed next.

Flared tubing. Two kinds of flares are generally used in aircraft plumbing systems, the single flare and the double flare. (See figure 2-12.) Flares are frequently subjected to extremely high pressures; therefore, the flare on the tubing must be properly shaped. A flare made too small produces a weak joint, which may leak or pull apart. If made too large it interferes with the proper engagement of the screw threads on the B nut. Check the flare by sliding the sleeve into position over the flare. The outside diameter of the flare should extend approximately one-sixteenth inch beyond the end of the sleeve, but should not be larger than the major outside diameter of the sleeve. This can be seen by looking at the flared tube assembly in figure 2-13. A double flare should be used on soft aluminum

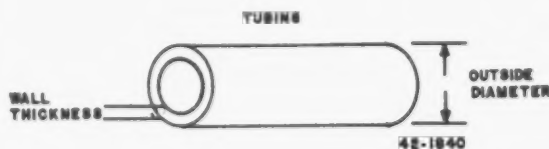


Figure 2-11. OD and wall thickness of tubing.

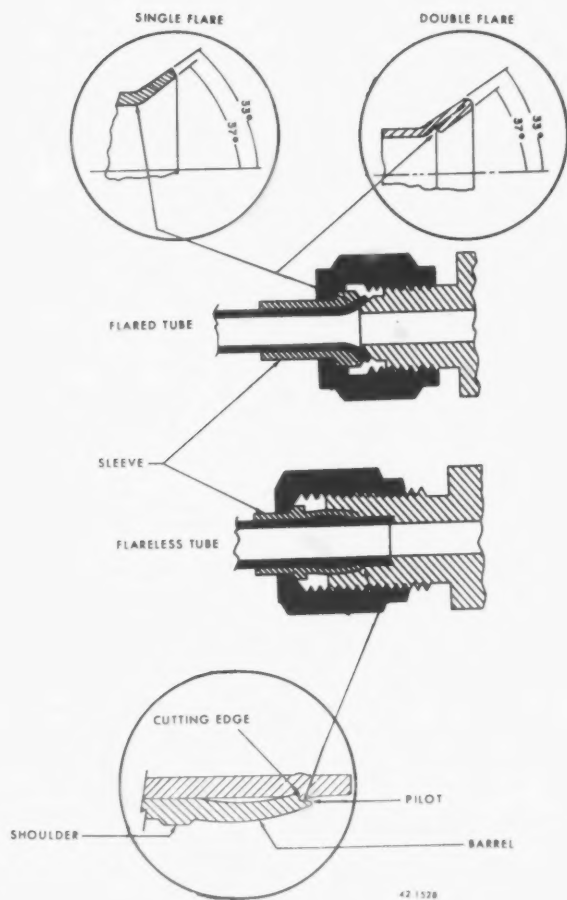


Figure 2-12. Flared and flareless tubing.

tubing for all sizes from 1/8 to 3/8 inch outside diameter tubing. This is necessary to prevent cutting off the flare, and the failure of the tube assembly under operating pressures. Double flaring is not necessary on steel tubing.

Refer again to figure 2-12. When installing a flared tube assembly, be sure it is properly aligned prior to tightening; never pull it into place with the nut. If the tube assembly is misaligned, it becomes prestressed and may leak during operation of the system. Start the B nuts on each end of the tubing by hand. Then tighten them to the proper torque.

Applying the proper torque to the B nut is very important. Overtightening may badly damage or completely cut off the tube flare. Also it may ruin the sleeve or the B nut. Failure to tighten it sufficiently can be equally as serious. This condition may allow the lines to leak under system pressure. A B nut should never be tightened when there is pressure in the line. This would cause an incorrect torque to be applied, which could damage the flare.

Besides this, the tube may separate from the B nut and cause injury to personnel.

MS flareless tubing. Manufacture of a flareless tube assembly involves an operation termed presetting. This is where the sleeve is permanently attached to the tube. The sleeve (shown in figure 2-12) has a shoulder, barrel, pilot, and cutting edge. During assembly (presetting), the sleeve cutting edge is forced inward, seating the cutting edge against the outer surface of the tube. The pilot guides the cutting edge and limits the depth of cut. The barrel becomes bowed as the B nut is tightened. Figure 2-12 shows the sleeves spring washer effect (bowed) when it is installed. This will prevent the loosening of the nut when severe vibration is encountered. Prior to installing an MS flareless tube assembly, the sealing surface of the sleeve that contacts the fitting body should be checked to insure that it is smooth, free from scores and cracks. Even though the sleeve cutting edge is embedded in the tube outside diameter, it is permitted to rotate on the tube assembly. The sleeve is also allowed a longitudinal movement back and forth if it doesn't exceed 1/64 of an inch.

When installing MS flareless tubing, the tube centerline should be in line with the centerline of the fitting to which it is connected. It should not have to be forced into position. Now tighten the nut with your fingers until a sharp rise in torque is noted. From this point, using a wrench, turn the B nut 1/6 turn (one flat on the B nut). Should a connection leak after installation, it is permissible to tighten the B nut an additional 1/6 turn. If after tightening the nut a total of 1/3 turn (two

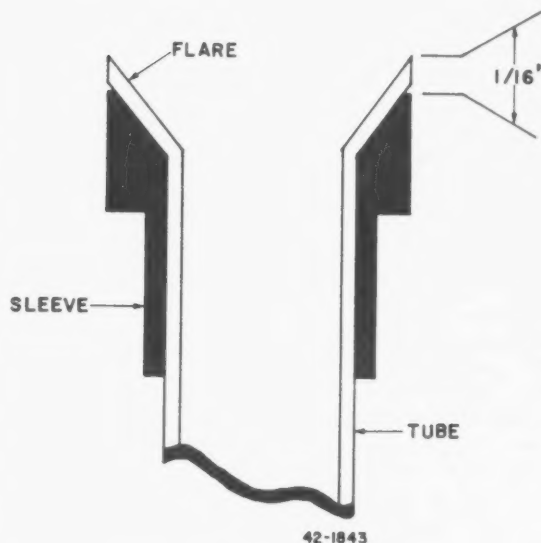


Figure 2-13. Sizing flare with sleeve.

flats on the B nut), leakage still exists, the assembly should be removed and the components of the tube assembly should be inspected for scores, cracks, presence of foreign material, or damage from overtightening. As with flared tube assemblies, it is important that the nut on MS flareless tube assemblies be tightened properly. Overtightening a leaking MS flareless fitting will deform the sleeve or tube. Once the sleeve or tube is damaged, the tube assembly will most likely leak. Remember, never exceed 1/3 turn on MS flareless tube assemblies.

Exercises (221):

Indicate whether the following statements are true or false. If false, explain why.

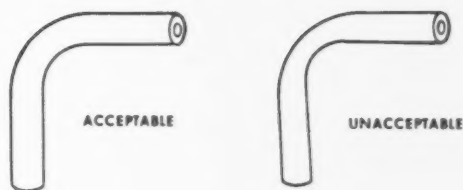
- 1. High-pressure hydraulic systems use aluminum alloy 6061 tubing.
- 2. All tubing used in the manufacture of rigid tubing assemblies is sized by outside diameters and wall thickness.
- 3. A number 5 tubing is 5/16 in outside diameter.
- 4. Flared tubing is frequently subjected to extremely high temperatures, therefore a flare made too small may leak or pull apart.
- 5. A double flare is used specifically on stainless steel tubing.
- 6. Overtightening a B nut on a flared tube assembly could badly damage the flare or cut it off completely.
- 7. The bow in the barrel assembly of a flareless tube sleeve will prevent the loosening of the B nut when severe vibration is encountered.

- 8. To stop a connection leak on a flareless tube assembly, it is permissible to tighten the B nut by turning it 1/2 turn (3 flats on the B nut).
- 9. The presetting of the sleeve of a flareless tubing assembly is done during the manufacture of that assembly.
- 10. If the sleeve of a flared tubing assembly is pushed up against the flare and the flare extends farther than 1/16 of an inch, the flare is too small.

222. Given situations that describe tubing damage, specify if repairs are needed and the type of repairs that will be made.

Tubing Damage. Damage such as chafing produces mechanical property changes in metal tubing that greatly reduces the ability to withstand internal pressure and vibration. Any visible chafing is cause for replacement of the tube assembly or damaged section thereof regardless of the type metal, type of system, or pressure ranges involved. Tubing with excessive flatness, wrinkles, or irregular bends should not be installed. Examples of correct and incorrect tubing bends are shown in figure 2-14. Any dent on the heel of a bend or more than 20 percent of the tubing diameter on a straight piece of tubing is cause for tubing replacement. A scratch/nick on straight sections of tubing should not exceed 15 percent of the wall thickness. A scratch/nick on the bend of a tube assembly should not exceed 10 percent of the wall thickness for systems with pressures of less than 500 psi, or 5 percent for systems with working pressures 500 psi or greater. If the nick/scratches are within allowable limits, they should be smoothed out. If the nicks/scratches are not smoothed out, consequent stress concentration under vibration will cause weakening and breaking at the nicked/scratched point.

Permaswage Repair Procedure. This procedure provides the capability for the permanent repair of damaged tube assemblies. As you know when an electrician finds a broken wire in an electrical circuit, he splices the two pieces of wire back together again instead of rewiring the complete circuit. Well, the permaswage repair procedure does basically the same thing, but instead of using a splice he uses a specially designed fitting which is mechanically swaged onto the tube by a hydraulically operated tool.



PERFECT BEND

FLATTENED BEND



WRINKLED BEND



KINKED BEND

42-1824

Figure 2-14. Correct and incorrect tubing bends.

When a new tube assembly is locally manufactured, it sometimes does not fit exactly as the original. In fact it might have to be made several times before the proper length and bends are achieved. Using the permaswage repair procedures, a lot of this can be eliminated. Refer to figure 2-15. Notice that the damaged portion of the tube assembly (pinhole, crack, scratch, or dent) is cut away. A swage fitting is installed and permanently attached between the two halves of the tube assembly. As you can see in figure 2-16, the bends, length, and angles should be almost the same as the original tube. For further instruction on the permaswage procedures refer to TO 1-1A-8.

Exercises (222):

1. A tube assembly installed in a system with a pressure of less than 500 psi has a dent in a straight section that is 5 percent of the tubing diameter. Is repair necessary, and if so, what type of repair will be done?
2. In a system with a working pressure of 1100 psi, a scratch that was determined to be 7 percent of the tube wall thickness was found. Is repair necessary, and if so, what type of repair will be done?

3. A tube assembly installed in a system with a pressure of less than 500 psi has a dent on the heel of a bend that is 10 percent of the tubing diameter. Is repair necessary, and if so, what type of repair will be made?

223. Specify what the markings on a hose indicate and what the requirements are for hose storage.

Bulk Hose Identification. Various types of hose assemblies are locally manufactured by the pneudraulic shop. The objectives in this discussion will be limited to the four types of bulk hose generally used for hydraulic and pneumatic systems.

MIL-H-8794 bulk hose. This is a medium-pressure rubber hose for use in hydraulic, fuel, and oil (petroleum base only) systems. The outer surface of the hose will be identified with yellow markings. Most pneudraulic rubber hose is marked (see figure 2-17) with the specification number, the size, the quarter and year of manufacture, and a 5-digit number identifying the manufacturer. These markings are in yellow-colored letters and numerals that indicate the natural lay (no twist) of the hose. They are repeated at intervals of not more than 9 inches along the length of the hose. The operating range of this hose is -65° to 200° F. Figure 2-17 shows the construction of medium-pressure hose (MIL-H-8794). It consists of a synthetic rubber

Pin hole leak or circumferential crack in tubing.

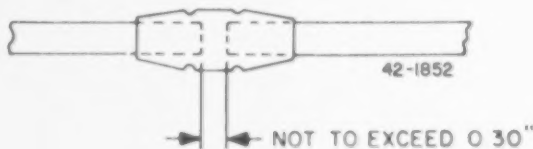


Figure 2-15. Permaswage fitting.

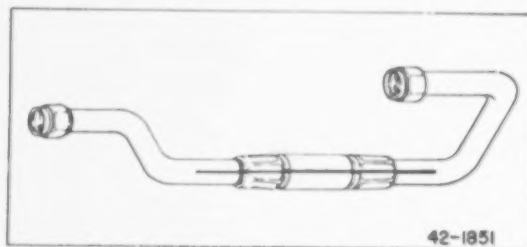


Figure 2-16. Repaired permaswage tube assembly.



Figure 2-17. Mil-H-8794 bulk hose.

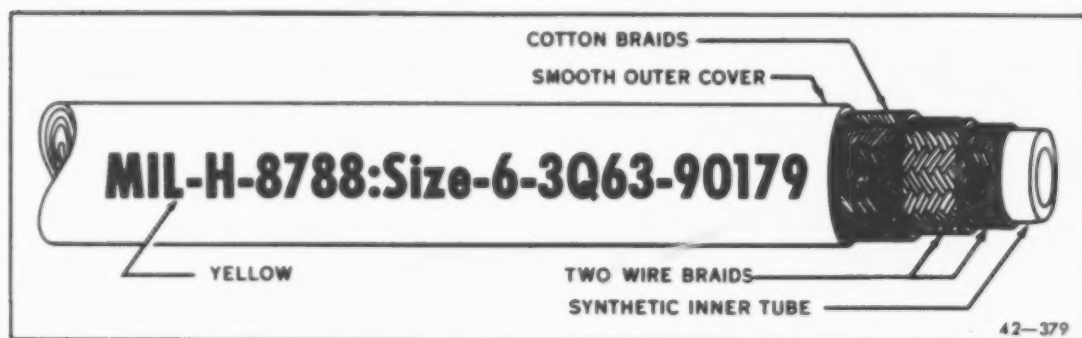


Figure 2-18. Mil-H-8788 bulk hose.

inner tube, impregnated cotton braid, single-wire braid, and impregnated cotton braid outer covering that has a rough finish.

MIL-H-8788 bulk hose. This is a high-pressure rubber hose for use in hydraulic systems. The outer surface of the hose will have yellow markings similar to the medium-pressure hose (MIL-H-8794) previously discussed (see figure 2-18). Notice that it is very similar in construction to the medium-pressure hose except for an additional wire braid and a smooth outside covering.

MIL-H-27267 bulk Teflon hose (tetrafluoroethylene). This hose is used in hydraulic and pneumatic systems which do not exceed 1500 psi, except as specified in TO 42E1-1-1. The operating range of Teflon hose is approximately -65° to 450° F. This hose is manufactured with a smooth bore (firm, waxy feeling) inner tube covered with corrosion-resistant steel wire braid. The hose is identified by a band (much like a band you might find around a birds leg) spaced at 3-foot intervals. It is marked with the specification number (MIL-H-27267), size (-10), operating pressure

(1500 psi), and the manufacturer's code number (50599).

MIL-H-83298 bulk Teflon hose. This Teflon hose is intended for use in aircraft high-pressure (3000 psi) systems. Bulk hose will be marked at 3-foot intervals with a band containing information similar to the Teflon medium-pressure hose (MIL-H-27267).

Hose size. As was mentioned previously, hose size is designated by a dash number (-4, -6, -8, etc.) stenciled on the side of the hose. This dash number does not denote the inside or outside diameter of the hose itself, but rather the size tubing it is used with. For example, a-8 hose is used with a -8 tubing. The reason for this is that the inside diameter of both -8 hose and -8 tubing is approximately the same.

Hose Storage. The storage life of medium- and high-pressure rubber bulk hose (MIL-H-8794 and MIL-H-8788) is calculated from the date of manufacture stenciled on the hose. As an example, 3Q74 indicates that the hose was manufactured in the 3rd quarter (July, August, September) of 1974. As a general rule the time limitation is 16 quarters

(4 years) from this date, for hose used on airborne equipment. Hose that is over 4 years old may be used on ground equipment. In addition, it should be stored so that the oldest hose will be used first. Teflon hose does not deteriorate with age, so it has an unlimited storage life.

Storage of hose in a straight position is preferred, but if necessary it can be coiled in a large noose, not to exceed the recommended bend radii. Hose must be stored in a dark, cool, dry place where it is protected from excessive heat and exposure to strong air currents. The hose must be stored away from electric motors or other equipment that gives off heat or ozone. Both ends of rubber bulk hose or hose assemblies must be sealed with caps or plugs to prevent entrance of foreign material. The ends of wire covered (Teflon) bulk hose should be covered with tape to prevent wire flareout and personnel injury while handling.

Exercises (223):

1. a section of bulk hose has these markings MIL-H-8788:-10;2Q75:90179. Specify what each marking means.
2. A section of bulk hose has these markings on bands spaced at 3-foot intervals: MIL-H-27267:-10:1500 psi:50599. Specify the type of hose and what each marking means.
3. What size hose would you use with size 10 tubing?
4. What is the storage life for hose used on airborne equipment?
5. What is the preferred method of storing hose?

224. State the advantage of using flexible hose in a pneudraulic system, then specify procedures in manufacturing a high-pressure rubber hose and medium-pressure Teflon hose assemblies.

Pneudraulic Hose Assemblies. Pneudraulic hose assemblies are used for the same purpose as tubing—to route the fluid to and from the various units. However, hose has one advantage over tubing—flexibility. For example, hydraulic pumps should always have a flexible hose attached to them. The vibration that is set up by an operating pump would ultimately cause rigid tubing to fail.

Flexible hose assemblies are fabricated by hand or by a hose manufacturing machine. The hose manufacturing machine is covered in a later chapter. The principles of hose fabrication are the same regardless of the method used.

The pneudraulic shop has been assigned the task of locally manufacturing all the hose assemblies used on an aircraft. If a hose for the lubricant system of an aircraft engine is leaking, the pneudraulic shop would more than likely manufacture it for the engine shop even though the engine shop would remove and replace the hose.

It would be difficult to cover the fabrication of all the hose assemblies used on the aircraft in this section. We will discuss however the fabrication of a high-pressure rubber hose and a medium-pressure Teflon hose assembly, as shown in figure 2-19.

Fabrication of high-pressure rubber hose assemblies. High-pressure hose assemblies are authorized for local manufacture. This is true only when qualified personnel and adequate equipment are available. Personnel assigned to manufacture high-pressure hose assemblies should be trained in assembly procedures. The safety hazards are increased greatly with the use of high-pressure hose.



HIGH PRESSURE HOSE ASSEMBLY PART NUMBER MS 28759-8-0154



MEDIUM PRESSURE TEFLON (TETRAFLUOROETHYLENE) HOSE ASSEMBLY

42-380

Figure 2-19. Types of hose assemblies.

This is true not only its manufacture but also in its installation.

Common tools and equipment needed for assembling high-pressure hose assemblies by hand are as follows: standard vise, oil can, hacksaw with a fine-toothed blade of 32 teeth per inch (or a hose cutoff machine), and appropriate open-end wrenches. Special tools and equipment needed is a mandrel for high-pressure hose. These mandrels come in sizes -4 through -16. In addition, you will also need a wire brush (or soft wire wheel) and a hose cutting jig.

The first steps in fabrication are to select the proper size bulk hose (MIL-H-8788), mandrel, and end fittings (MS28760 or MS28761). A high-pressure hose end fitting is shown in figure 2-20. In manufacturing high-pressure rubber hose, you never reuse end fittings or hose. After determining the correct length, cut the hose squarely. This is done by clamping it in a cutting jig and using the cutoff machine or a fine-toothed hacksaw. Then use compressed air to clear the hose of cutting residue. Figure 2-21, A, shows how to mark the hose to insure the proper outer covering removal. Place the socket against the hose as shown. Align the notch on the socket with the end of the hose and mark as shown in figure 2-21. This amount of hose outer cover is to be stripped. Now refer to figure 2-21, B. Using the knife as shown, cut around the hose through the outer cover to the wire braid. (Make certain that the cut is to the wire braid). Then slit this section of the outer cover lengthwise, as shown in figure 2-21, C. Next, pry up the outer cover with the knife. Then use the pliers to twist off the cover, as shown in figure 2-21, D.

Use a wire brush, as shown in figure 2-21, E, or soft wire wheel to remove all the rubber particles adhering to the wire braid. Be extremely careful during this operation to insure that the wire braid is not loosened, frayed, or flared when brushing. Next, apply adhesive Spec. MMM-A-1617 Type II on exposed portion of the wire braid. Place the socket in a vise and screw the hose into it, turning counterclockwise until it bottoms. This is shown in figure 2-21, F. Then back off the hose 1/4 turn. A good rule is to mark the hose immediately behind the socket with a grease pencil. This will indicate if the hose is being pushed out of the socket during assembly. Avoid excessive turning of the hose in aluminum sockets. It will tend to grind away material from the buttresses inside the socket. Next, insert the mandrel into the nipple assembly. Lubricate the inside of the hose and nipple threads liberally, using Spec 30 oil. Military Specification MIL-L-7870 is one type of lubricant you can use. These previous two steps are illustrated in figure 2-21, G. Then screw the nipple into the socket and hose, using a wrench on the nipple hex, as shown in figure 2-21, H. The nipple hex should bottom against the socket face. The B nut should rotate

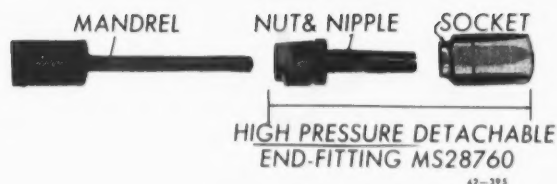
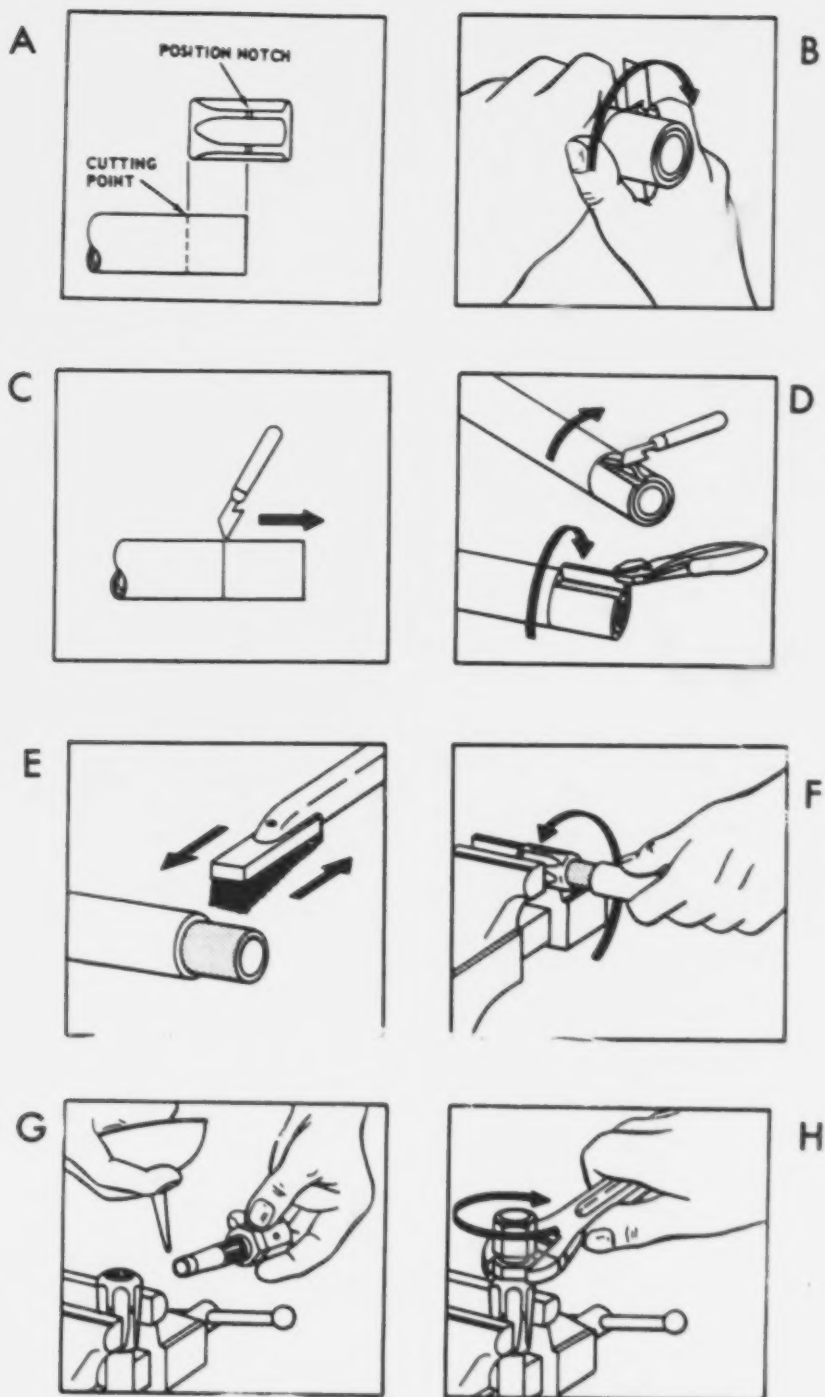


Figure 2-20. High-pressure hose fitting with mandrel.

freely when the mandrel is removed. The clearance between the nipple hex and the B nut is provided for when the end fittings are manufactured. The B nut is held on the nipple with a wire retainer that maintains the proper clearance. After installing both end fittings, clean the hose assembly internally, using dry, compressed air. Visually inspect the assembly internally to insure that there is no cutting of the inner tube. Also, check for a minimum bulge diameter of the inner tube. (Minimum bulge diameters for the various sizes of hose are found in TO 42E1-1-1.)

Fabrication of medium-pressure Teflon hose assemblies. Common tools and equipment needed for assembling medium-pressure Teflon hose assemblies by hand are as follows: standard vise, hacksaw (with a fine-toothed blade of 32 teeth per inch), hose cutoff machine, masking tape, wrenches (open-end or adjustable jaw), and a hydraulic testing unit. Assembly mandrels are not needed for hand assembly of fittings with this hose. Teflon hose assemblies (MIL-H-25519) are comprised of MIL-H-27267 bulk hose and MIL-F-27272 fittings. Lubrication is not needed for MIL-F-27272 fittings; components are permanently dry-film lubricated. Now let's discuss the use of these tools and equipment by showing how hose assemblies are fabricated.

One of the first steps in the fabrication is to select the proper size bulk hose and end fittings. Medium-pressure fittings may be reused if serviceable (check closely the sealing surface of sleeve, nipple, and socket for damaged threads or distortion). NEVER reuse hose Specification MIL-H-27267. Next, we need to determine the length of hose to cut off. Refer to figure 2-22 for the end fitting cutoff allowance. The cutoff allowance for each end must be subtracted from the assembly length. For example, suppose we wanted to make a size 4 hose with straight fittings 15 1/2 inches in length. The cutoff allowance for each end is 0.74 inch times 2 end fittings, which would be 1.48 inches. This requires 14.02 inches for the hose without fittings. To prevent flareout of the wire during cutting, place a piece of masking tape around the hose cutoff point. After the hose is cut to the proper length, the tape must be removed. Figure 2-23 shows the socket, sleeve, and nipple assembly that make up the end fitting for Teflon



42-1823

Figure 2-21. Procedures for manufacturing a high-pressure rubber hose.

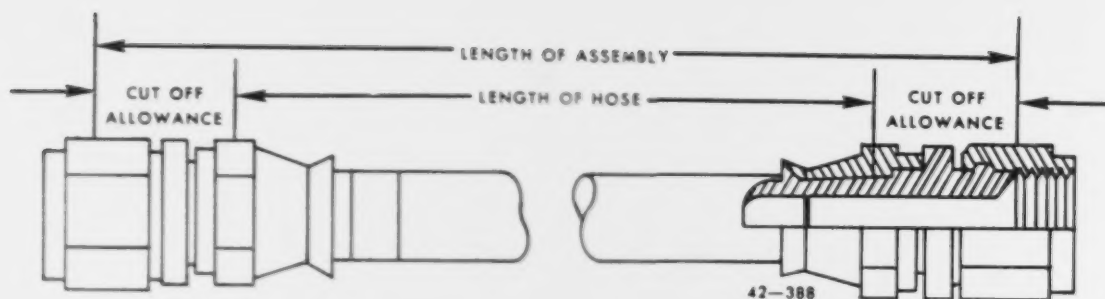


Figure 2-22. Teflon hose assembly measurements.

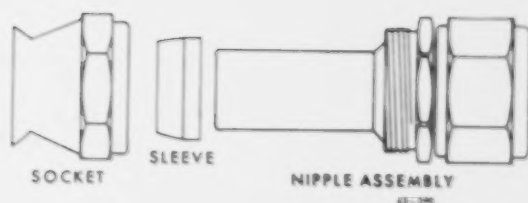


Figure 2-23. Teflon medium-pressure end fitting.

hose assemblies. Place two of the sockets skirt to skirt as shown in figure 2-24. Then work the hose through the sockets with a pushing, twisting motion. Inserting the "neck down" end will make assembly easier. Remove the hose and sockets from the vise. Place the nipple assembly in the vise. Push the hose onto the nipple, as shown in figure 2-25, to size the tube inside diameter (I.D.). This aids in separating the wire braid from the tube. Remove the hose from the nipple. Carefully insert the sleeve between the wire braid and tube outside diameter (O.D.). Insure that no wires are trapped between the sleeve and tube O.D. Complete inserting the sleeve by pushing the end of the sleeve against a flat surface. Do this until the tube bottoms against the shoulder in the sleeve I.D. (see figure 2-26). Next, size the tube to the nipple. This is done by pushing the tube over the nipple until the sleeve bottoms against the nipple chamber. Remove and recheck to be sure that sleeve is still in place. Again push the tube onto the nipple and bottom of sleeve against the nipple chamber. Slide the socket forward and engage the threads by hand. Remove the assembly from the vise and regrip the socket in the vise. Using a wrench on the nipple, tighten it to a gap of 1/32 inch from the socket; gap may vary from 0.025 to 0.045 inches (see figure 2-27). Install the other end fitting in the same manner. Then clean the inside of the hose assembly. Use dry, compressed air to blow out foreign matter. Again inspect the hose assembly for any foreign material.

The next stop is to proof pressure check the hose assembly.

Exercises (224):

1. What is the advantage of using hose over tubing in a pneumatic system?
2. Specify the two parts of a high-pressure fitting.
3. How is high-pressure hose cut?
4. What should be done to determine the proper amount of rubber (outer covering) that must be removed?
5. How deep is the outer covering of a high-pressure hose cut?
6. Why should excessive turning of the high-pressure rubber hose in the aluminum socket be avoided?

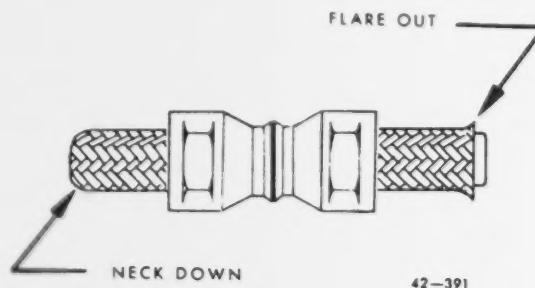


Figure 2-24. Sockets, skirt to skirt.

7. What common tools and equipment are needed for assembling medium-pressure Teflon hose assemblies by hand?
8. What should be done to prevent flareout of Teflon hose during cutting?
9. Where is the sleeve inserted on medium-pressure Teflon hose?
10. What is the acceptable gap between the socket and nipple at the Teflon hose assembly?

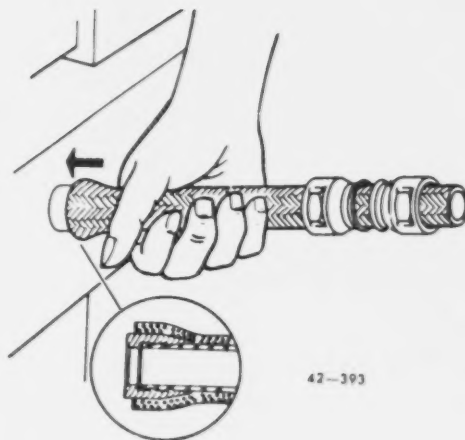


Figure 2-26. Inserting sleeve.

225. Specify the procedures used to proof pressure test, mark, and assign part numbers to hose assemblies.

Proof Pressure Test. Proof pressure testing a hose includes applying pressure to the hose much higher than the normal operating pressure. For example, a medium-pressure hose size 8 has an operating pressure of 2000 psi, and it is proof pressure tested at 4000 psi. Proof pressure charts can be found in TO 42E1-1-1. They list the hose proof pressure according to its material, size, and in some cases the system that it will be used in, such as egress, fuel, oil, etc. Any suitable hydraulic testing unit capable of building pressure to the recommended values may be used. A very important precaution when proof testing a hose is to use a heavy plastic cover over the hose assembly. This provides protection for the person inspecting the hose in case it should rupture.

The time the hose should be held on a proof pressure test is listed below

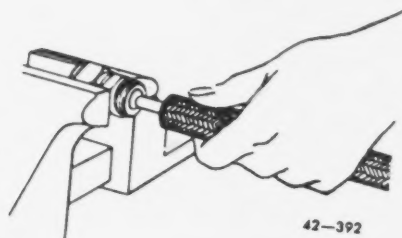


Figure 2-25. Size tube, and flare braid.

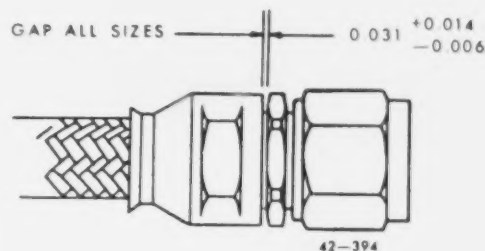


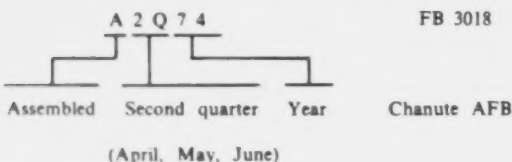
Figure 2-27. Tightening socket.

Hose	Minimum time	Maximum time
Medium-pressure hose	30 seconds	5 minutes
High-pressure rubber hose	1 minute	5 minutes
High-pressure Teflon hose	30 seconds	5 minutes

While maintaining this pressure, the assembly is checked for evidence of seepage. Hose assemblies showing evidence of seepage will be rejected. Under no condition will any adjustment of the end fitting be made after the hose assembly has been proof pressure tested. After the hose has been proof pressure tested it should be cleaned by flushing or dipping the hose in cleaning fluid, drained and blown dry with compressed air. Immediately after this, the hose should be capped or plugged to prevent foreign matter from entering the hose.

Marking Hose Assemblies. Because, the stenciling on the side of bulk rubber hose wears off or fades with time, a method was conceived to provide a positive date for replacement purposes. This is usually done with an electric vibrator pencil (etcher) on all rubber hose assemblies.

Assume that a hose has just been locally manufactured by your shop. The date the hose assembly was manufactured will be etched on one flat surface of each socket, as shown below.



To indicate which base or facility manufactured the hose the local base account code, such as FB 3018 for Chanute AFB, will be placed on another flat surface of each socket. When medium-pressure end fittings are reused, previous etchings must be obliterated, and newer dates etched on the next flat surface of the socket.

Now let's say that we ordered and received a hose assembly from supply that wasn't manufactured on your base. In fact there isn't any markings whatsoever on the hose sockets. All that will need to be done is etch the date the hose is going to be installed on the aircraft on one flat surface of each socket. The installation date will be indicated by quarter of year, the letter "Q" and last two digits of current year (2Q76).

If a locally manufactured hose is manufactured and placed in supply, it should have the assembled date and base account code placed on the hose sockets. When this hose is drawn out of supply, the manufactured date (assembled date) will be considered as the installation date, and no other marks need be placed on the hose assembly.

Assigning Part Numbers to Hose Assemblies. Completed hose assemblies are given part numbers depending on the type of bulk hose and fittings used. Refer to the medium pressure part number MS28741-8-0146 in figure 2-28. The specification number MS28741 tells us that medium-pressure rubber bulk hose (MIL-H-8794) was used to manufacture this hose assembly using MS28740 hose fittings. If the specification number was MS28759 this would tell us that we are using high-pressure rubber bulk hose (MIL-H-8788) with MS28760 hose fittings. Again look at hose part number MS28741-8-0146 in figure 2-28, as we continue discussing it. The -8 of the part number in figure 2-28 denotes the size of the hose and fittings. The numerals -014 denotes the length of the assembly in inches. The last digit, 6, is in eighths of an inch. A quick reference to this part number as shown in figure 2-28 tells us we have a medium-pressure hose assembly, size 8, 14 $\frac{3}{4}$ inches long.

The flexible hose assemblies have been made and marked. In the next section we shall look at

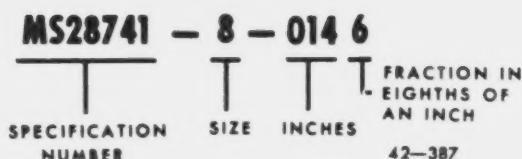
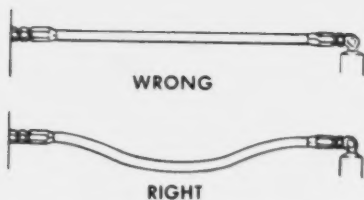


Figure 2-28. Part number of medium-pressure rubber hose assembly.

installation procedures and the acceptable flexible hose assembly damage limits.

Exercises (225):

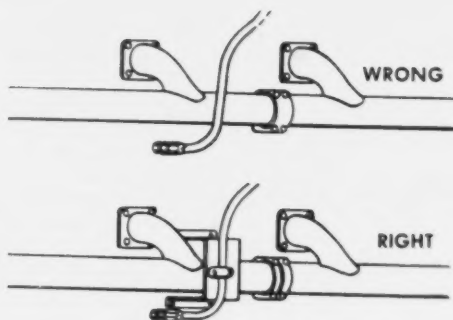
1. What type of testing unit is used to make a hose proof pressure test?
2. Why must a heavy plastic cover be placed over the hose assembly when proof testing it?
3. What is the maximum time limit a high-pressure rubber hose should be held on proof pressure test?
4. What must be done with hose assemblies that show evidence of seepage?
5. What is done with a hose assembly after it is proof pressure tested?
6. What would the etching "2 Q 76" from one flat of each hose socket indicate?
7. What should be etched on a hose socket for a hose assembly that was locally manufactured and placed in supply?
8. Specify what the hose assembly part number MS28759-8-0154 tells you about the hose assembly.



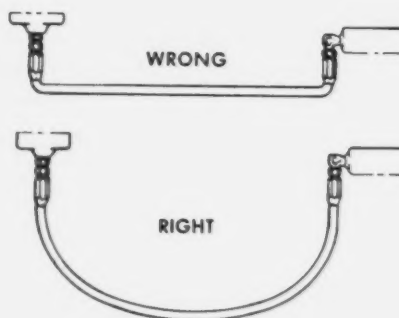
1. REMEMBER THAT THE HOSE WILL CHANGE IN LENGTH FROM +2% TO -4% WHEN PRESSURIZED. PROVIDE SLACK OR BEND IN THE HOSE TO COMPENSATE FOR ANY CHANGES IN LENGTH WHICH MIGHT OCCUR.



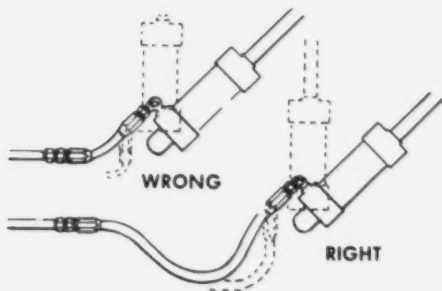
4. IF HIGH OPERATING PRESSURES ARE APPLIED TO A TWISTED HOSE, THE HOSE MAY FAIL OR THE ATTACHING NUT BECOME LOOSE.



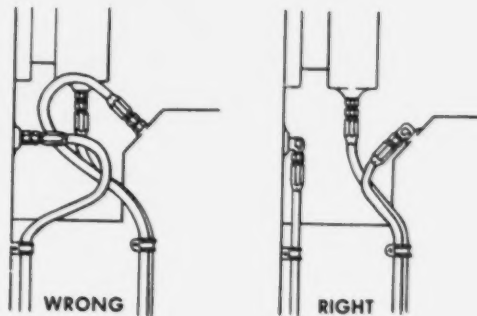
2. WHEN HOSE LINES PASS CLOSE TO A HOT EXHAUST MANIFOLD, PROTECT THE HOSE WITH FIRE PROOF BOOT OR METAL BAFFLE.



5. KEEP THE BEND RADIUS OF THE HOSE AS LARGE AS NECESSARY TO AVOID KINKING OF LINE AND RESTRICTION OF FLOW.



3. WHEN A HOSE ASSEMBLY IS TO BE SUBJECTED TO CONSIDERABLE FLEXING OR VIBRATION, REMEMBER THAT THE METAL HOSE FITTINGS ARE NOT PART OF THE FLEXIBLE PORTION.



6. USE ELBOWS AND ADAPTERS TO INSURE CLEANER INSTALLATIONS FOR EASY INSPECTION AND MAINTENANCE.

42-1829

Figure 2-29. Installation of hose assembly.

226. Select the illustrations that depict improper hose installation and the hose within acceptable damage limits.

Installation of Flexible Hose Assemblies. Flexible hose must not be twisted on installation, since this reduces the life of the hose considerably and may cause the fittings to loosen as well. Twisting of the hose can be determined from the identification markings stenciled along the length of rubber hose assembled. These markings should not spiral around the hose as shown in figure 2-29.

The minimum bend radius for flexible hose varies according to the size and construction of the hose, and the pressure under which the hose will operate. Tables showing minimum bend radii for all types of installations are provided in TO 1-1A-8. Bends that are too sharp will reduce the service life of flexible hose, and may even restrict the flow of fluid through the hose.

Flexible hose should be installed so that it will be subject to a minimum of flexing during operation. Hose must be supported at least every 24 inches. Closer supports are preferred. A flexible hose should never be stretched tight between two fittings. Some slack should be allowed to provide freedom of movement because hose contracts in lengths and expands in diameter when pressure is applied.

Inspection of Flexible Hose. Whereas all rubber hoses must be inspected for aging and deterioration, Teflon hose, being inert, is exempt from shelf-life control. For this reason we have divided the inspection of flexible hoses into two broad areas which covers Teflon hoses and rubber hoses.

Teflon hose. Teflon hose assemblies must be visually inspected for leakage, kinking and wire-braid damage according to aircraft inspection requirements.

Kinking results when hose is bent to a shorter radius than its characteristics allow. This is a common cause of failure, because Teflon hoses becomes weak at this point. After a hose has been on an aircraft for a period of time, it tends to assume the shape of the position in which it is installed. Exercise care in removing these lines to prevent straightening that could result in kinking. A kinked hose should not be installed since this could result in a possible failure at point of kink.

Separation of the wire braid from the teflon inner tube is cause for hose replacement. Also, if the wire braid is damaged excessively, the hose should be rejected. Wire-braid damage is dependent on the amount of system pressure. In hose assemblies which operate at 500 psi and above, excessive wire damage consists of two or more broken wires in a single plait, or six or more wires per assembly (or per foot when assemblies are longer than 12 inches). For further information on wire-braid damage refer to TO 42E1-1-1.

Rubber hose assemblies. Besides being replaced for leakage, rubber hose assemblies are changed periodically due to the hoses age (time change). Hose assemblies made from metal-reinforced bulk hose (MIL-H-8794 and MIL-H-8788) should be replaced when the cotton-braid or rubber coverings become frayed or chafed to the point that the metal reinforcement is exposed or damaged. It is also replaced when the outer cover becomes loose.

Exercises (226):

- Using figure 2-30, select the illustration that depicts the hose within acceptable damage limits. Report your observations.

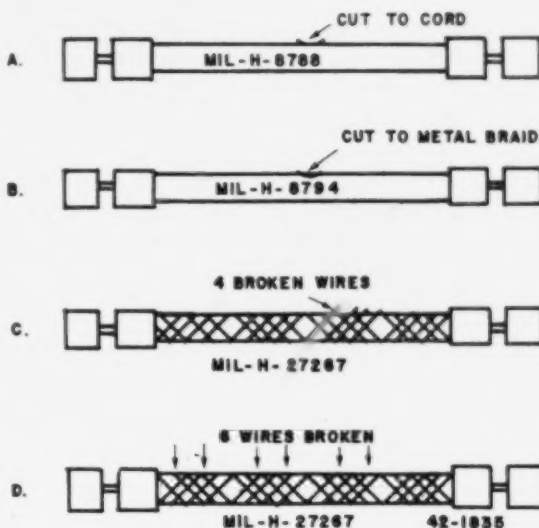


Figure 2-30. Objective 226, exercise 1.

- -
 -
 -
- Using figure 2-31, select the illustrations that depict incorrect hose installation. Report your observations.

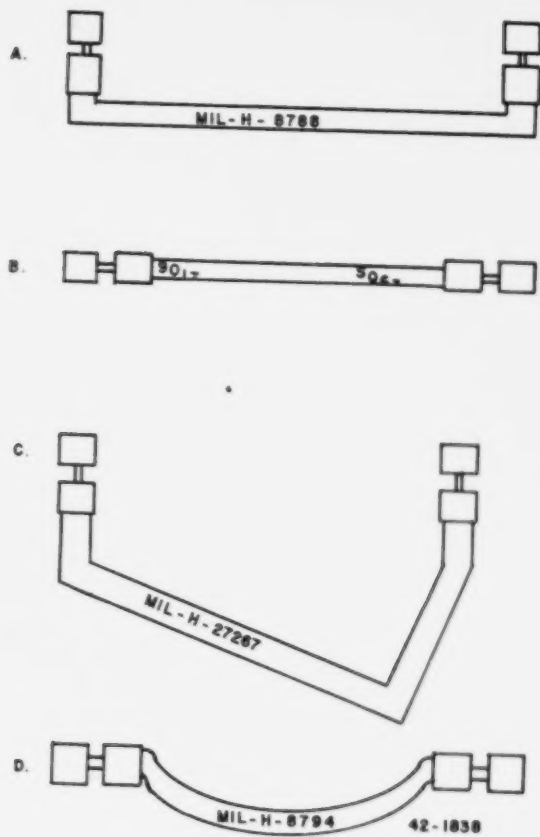


Figure 2-31. Objective 226, exercise 2.

- a.
- b.
- c.
- d.

227. Point out the use and design characteristics of identification tape and specify areas where it should be installed.

Color Coded Tape. Each fluid line in the aircraft is identified by color coded tape, to make it easier to recognize its contents. Figure 2-32 shows the

common systems and their color codes which you will encounter. The tape is approximately 1 inch wide, upon which word(s), color(s), and geometric symbols are printed. Three-fourths of the total width on the left side of the tape has a code color or colors that indicate the contents of the line. In some cases the function of the line is printed in English across the colored portion of the tape. The right-hand one-fourth of the identification tape contains a geometric symbol. These symbols, like the color coding are different for each type of fluid used on the aircraft. The symbol is to insure that all technicians, whether English speaking or not, who may be colorblind will be able to positively identify the line contents by the geometric design.

In figure 2-33 is a sample of a fluid line with an identification tape applied. The blue and yellow color coding and the geometrical design (circles) identifies the tube as a hydraulic system line. The arrows indicate the direction of fluid flow, and the lettering placed between the arrows defines the function of the line as "UTILITY RETURN."

Warning symbol tapes, $\frac{3}{4}$ inch wide, shall be applied to those lines whose contents are considered to be dangerous to maintenance personnel. Warning tapes are to be placed adjacent to system identification tapes.

Location of tape. Line identification tape should be applied when new tube or hose assemblies are installed. If the tape is missing or illegible it should be replaced. Exercise care when applying identification tape on hoses or tube assemblies to insure that arrows indicating direction of flow are installed correctly. Identification tape should be installed on each line or hose 24 inches or shorter.

If the line or hose is longer than 24 inches, it should have one identification tape placed at each end of the line or hose. Additional identification tape shall be applied so that at least one tape is visible in each compartment, or on each side of a bulkhead.

Identification tape is not used on lines submerged in fluid, where they could contaminate the system if they fell off, or in engine compartments for the same reason. For such locations, the lines should be painted the color code, without the geometrical symbol.

Exercises (227):

1. What is the purpose of having identification tape?
2. What is the geometric symbol on identification tape used for?

3. What would be the least amount of identification tape placed on a line that was 17 inches long, that went through a bulkhead?

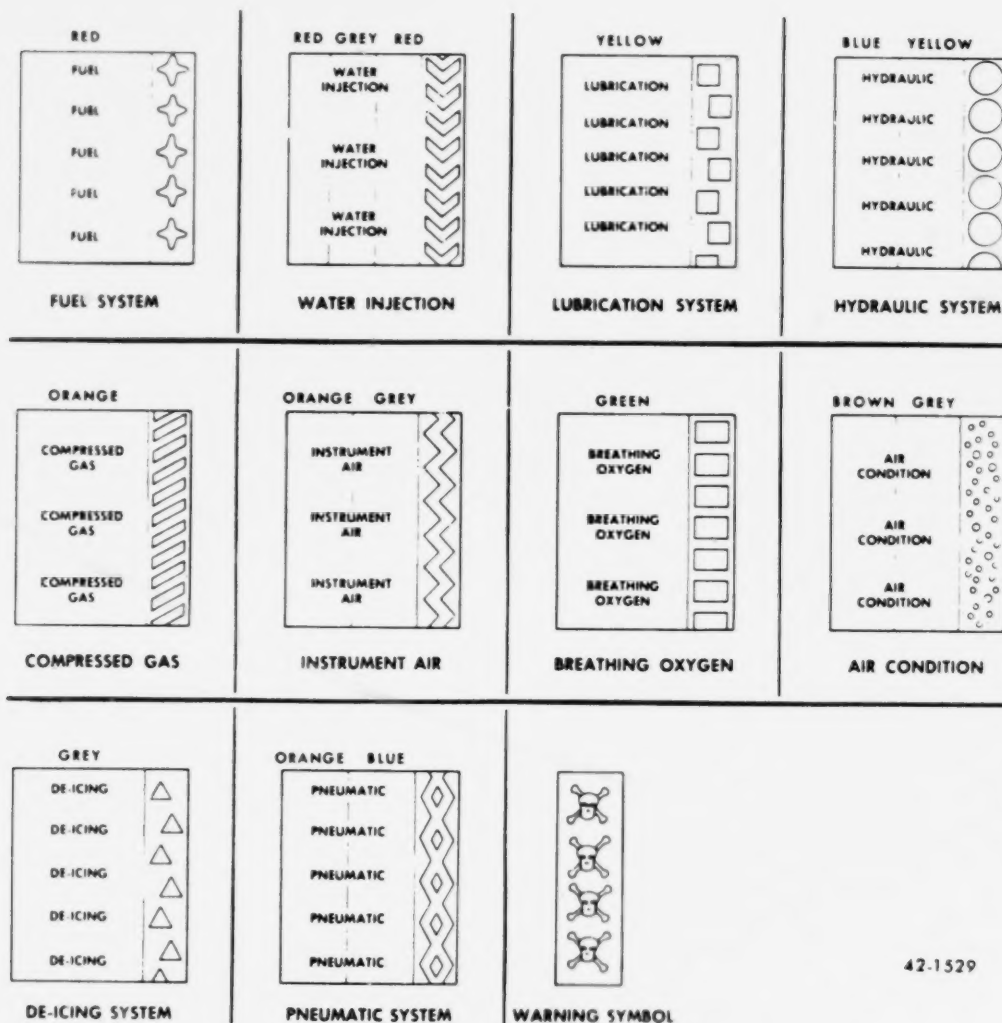
2-3. Hardware

Hardware is a broad term used to describe a number of items that do not fall into any other classification. In this selection we are going to talk about MS and AN settings, the types of threads they use, and some general installation procedures. In addition, we will discuss nuts, bolts, washers, and some safetying devices.

228. Point out the use and constructional features of fittings.

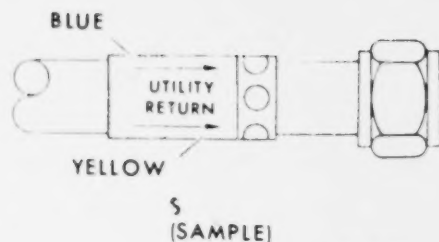
Fittings. Hydraulic and pneumatic fittings are used to provide a simple connection between components, tubing, and hose. Two major types of fittings used in aircraft are the standard AN (Air Force-Navy) and MS (Military Specification) fittings. Both types are manufactured in many different shapes and designs. They may be either male, female, or a combination (male on one end and female on the other).

Flared (AN) fittings. Flared fittings come in many different shapes. Figure 2-34 shows just a few of the available designs. The AN fitting shown in figure 2-35 has a 37° flared (beveled) face to which the tubing is fitted. This flared area of the fitting is the sealing surface when it is connected to tubing or hose. Farther down the fitting is a recess that is the



42-1529

Figure 2-32. Color codes.



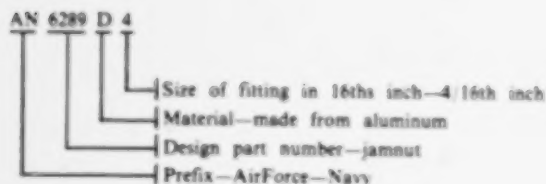
32-766

Figure 2-33. Fluid line with tape.

sealing surface when it is screwed into another fitting or component. A seal will have to be installed in this recess in order to form a fluid tight seal. Any imperfections on these sealing surfaces could cause a leak. Standard AN fittings are manufactured from aluminum alloy and steel. For identification purposes only, aluminum alloy fittings are colored blue, and steel fittings are black. The material from which a fitting is made can also be identified by its part number. As an example:

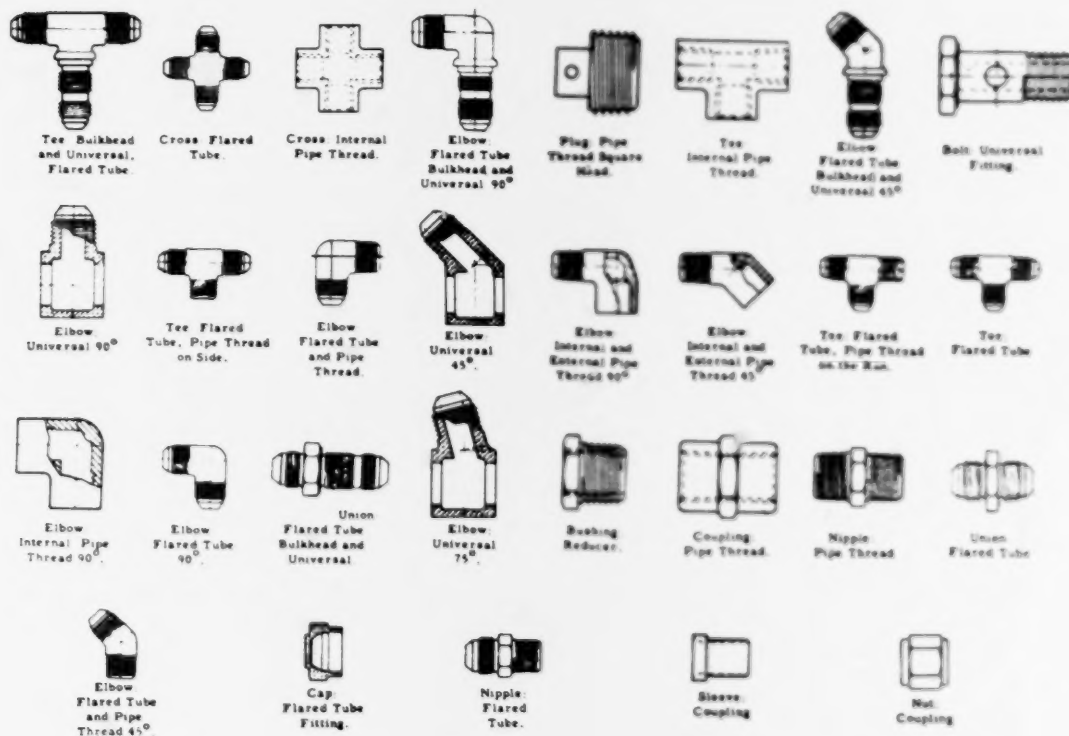
AN6289-4 is made from carbon steel
AN6289D4 is made from aluminum alloy

Notice the absence or addition of a letter following the part number designates the material it is made from. The complete part number, denotes its design, material from which manufactured, and its size.



Flareless (MS) fittings. MS flareless fittings are designed primarily for high-pressure (300 psi) systems that are subjected to severe vibrations and fluctuating pressures. Their use is limited to fittings up to size 16 (1 inch). Above 1 inch, An fittings are used. Systems using tubing larger than 1 inch would most likely be low pressure.

Like the AN flared fittings the MS flareless fittings comes in many shapes, sizes, and designs. (See figure 2-36.) The MS flareless fittings have straight (machine) threads like the standard AN



42-370

Figure 2-34. AN fittings.

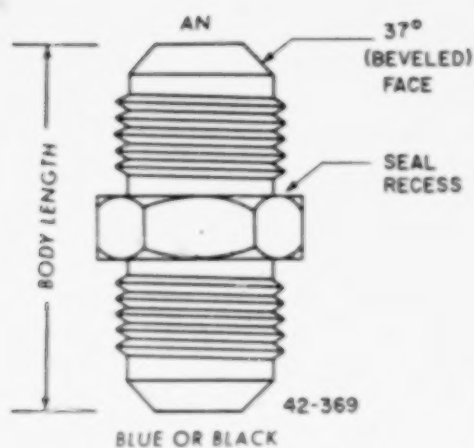


Figure 2-35. AN union.

flared fittings. Hence, they will mate with existing AN internal threads in valves and other equipment.

Notice in figure 2-37 that the fitting consist of an externally threaded port with an internal cone seat. The cone seat is set at a 24° angle. There is a ledge at the base of the cone seat where the tubing bottoms as it is forced into the fitting. This ledge (reverse angle tubing seat) is set at an angle to prevent excessive inward collapse of thin walled tubing when the fitting is tightened.

MS flareless fittings made of aluminum are colored yellow, green, or brown. Steel MS flareless fittings are silver colored (natural cadmium-plated). The method of making up part numbers for MS flareless fittings is the same as for AN flared tube fittings. A number is added to the basic part number to indicate the O.D. of the tubing it is used with. A letter placed after the basic part number denotes the type of material it is made from.



Figure 2-36. MS fittings.

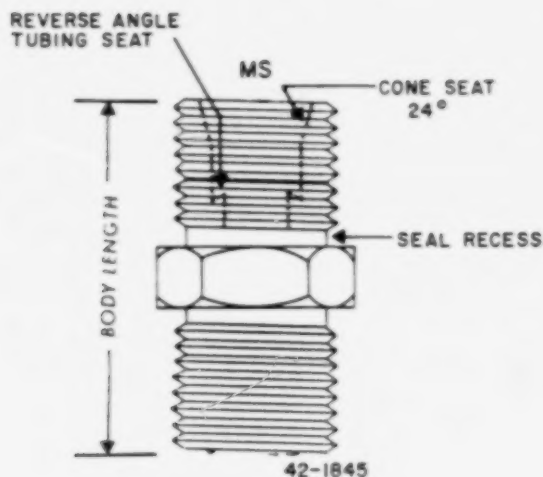


Figure 2-37. MS union.

Exercises (228):

1. What is the purpose of the recess on an AN fitting?
2. What color is an An aluminum fitting?
3. What can the part number of a fitting tell you?
4. Primarily, for what were MS fittings designed?
5. What type of threads are used on the AN and MS fittings?
6. Of the two fittings discussed which one has an internal seat?

229. From indications given, specify the possible cause for the problem.

Fitting Installation. A fitting, depending on its type and use, will have either pipe threads or machine threads. (See figure 2-38).

Pipe thread fittings. Pipe threads, similar to those used in ordinary household plumbing, are

tapered. When two pipe fittings are joined, a male into a female, their threads form a seal. When pipe thread fittings are used, an antiseize material (Teflon tape or equivalent) should be used to prevent seizing and leakage. The antiseize material should be applied to the male threads only. Take care that the antiseize material does not get on the end of the fitting where it may enter and contaminate the system. A good rule to follow is to omit applying antiseize material on the first two threads. When installing pipe thread fittings, be careful not to tighten them too much; this could damage the threads or crack the part in which the fitting is being installed.

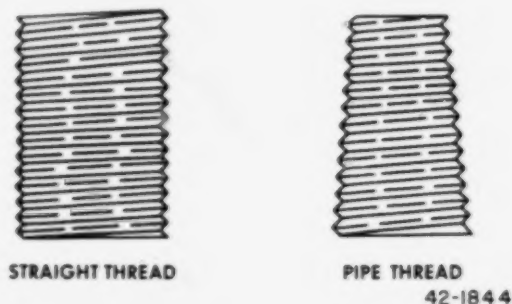
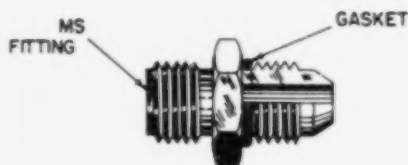
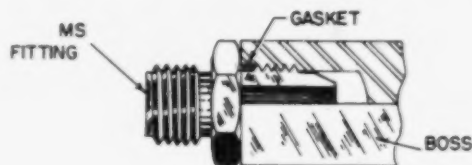


Figure 2-38. Pipe or straight threads.



GASKET INSTALLED



FITTING INSTALLED

TUBE - TO - COMPONENT

42-1822

Figure 2-39. Installing seal on adapter fitting.

Machine threads. Machine threads have no taper, instead, the threads are straight, similar to those used on nuts and bolts. This type of thread is used to draw connections together rather than to form a seal. Some other method must be used to make the connection fluid tight. Let's look at how two fittings, the adapter fitting and universal fitting are made fluid tight.

Universal fittings. Refer to figure 2-40. The first step in the installation procedure is to install the jamnut onto the threads of the fitting. Be sure to use the proper jamnut. If a backup ring is going to be used, you must use a jamnut with a recess (AN6289). The recess can be identified by an indentation on the outer circumference of the nut.

Adapter fitting. In figure 2-39 it shows an MS to AN adapter. In order to install this fitting into the component boss, the proper seal is selected, lubricated (with system fluid) and installed in position as shown. Be careful not to damage the seal while forcing it over the fittings threads. The fitting is then screwed into the boss of the component unit it bottoms, then torqued to TO specification. Without a seal this type of connection would leak.

Work the backup ring (MS9058) in the recess in the nut, then lubricate with system fluid and install the gasket (MS28778). Turn the nut down until the gasket is pushed firmly against the lower threaded section of the fitting. This is shown in the center illustrated in figure 2-40. Screw the fitting into the boss by hand and at the same time keep the nut

turning with the fitting until the gasket contacts the boss. This point can be determined by a sudden increase in torque (see bottom illustration of figure 2-40). With the fitting in this position, put a wrench on the nut to prevent its turning. Then turn the fitting in $1\frac{1}{2}$ turns. Now, position the fitting (if it is an elbow or tee) by turning it in not more than one additional turn. Finally, hold the fitting and turn the nut down tightly against the boss to the required torque. There must be no extrusion of the backup ring or seal. In many cases leaks have developed because of the improper installation of universal fittings. One of the reasons a universal fitting might leak, is that the jamnut is not positioned properly. This causes the seal to ride up on the threads, which cuts the seal. Another reason is that the jamnut might become stripped, which is caused by insufficient thread grip when the jamnut is torqued to the proper value. Instances cited above are reasons why it is so important to take the time to properly install a universal fitting.

Exercises (229):

1. If you had trouble removing a pipe thread fitting, what could be that problem?
2. If after removing a pipe thread fitting from an aircraft, you noticed that a portion of the antiseize material was lodged inside the component, what was done wrong during installation?
3. If while tightening the jamnut on a universal fitting, you noticed that it keeps turning and doesn't seem to bottom, what is the cause for the problem?
4. You are performing a pressure check after installing a rubber seal on a fitting. You notice that the fitting is leaking even though you installed a new seal. What could be wrong?

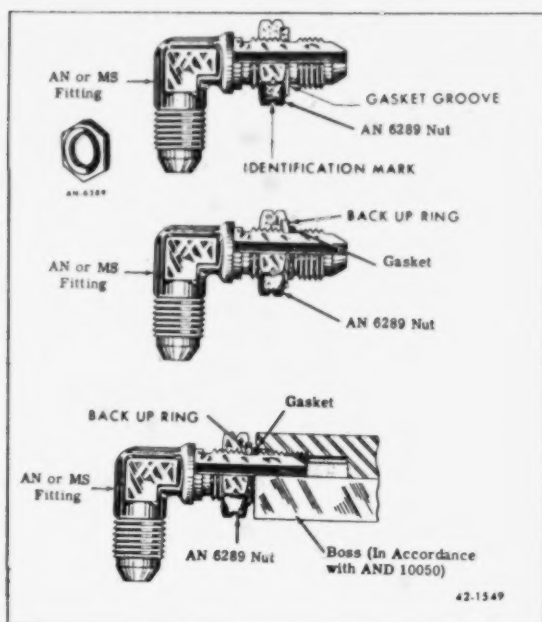


Figure 2-40. Installing universal fitting.

230. Specify characteristics and uses of the various hardware items and securing devices.

Aircraft Bolts. Most bolts used in aircraft structures are general-purpose AN (Air Force-Navy Standard), NAS (National Aircraft Standard), internal wrenching, or close tolerance bolts. When dimensional and strength requirements demand special bolts, aircraft manufacturers must make

them. Since these bolts are made for a particular purpose, you must use similar bolts in replacement. Such special bolts are identified by the letter "S" stamped on the head. Head markings on other bolts may indicate either the bolt type or the material from which it is made. Bolts are usually made of cadmium or zinc-plated nickel steel, bronze, dural, or aluminum alloy.

Generally, when a bolt is installed, the grip length (unthreaded portion) should be equal to the thickness of the material being joined. Because it is not always possible to observe this rule, certain variations are allowed. If one piece of material is thicker than the other, you may allow two threads to bear on the thicker piece. You can use bolts of slightly greater grip length if you use washers underneath the cut or bolthead. Use aluminum alloy washers with steel bolts on dural parts, except in case of high torque values. To prevent corrosion, use steel washers on steel parts.

The size of a bolt is stated in terms of length, diameter, and threads per inch. (See figure 2-41.) A bolt 2 inches in length, 1/4 inch in diameter, and having 28 threads per inch would be called a 2-inch bolt, 1/4 by 28. Bolts 1/4 inch in diameter, or greater, are specified by actual diameter measurement in inches or fractions of an inch. Bolts of less than 1/4 inch in diameter are specified by a number; for example, size 12 is the next size smaller than 1/4; then follow sizes 10, 8, 6, 4, and 2, respectively.

Bolts are made in so many shapes and varieties that a clear-cut method of classification is difficult. For the sake of simplicity, they may be roughly classified by the shape of the bolthead.

Hexhead. The hexhead bolt is available in a drilled (for safety wire) or undrilled head. It is also available in thin heads for use in tight places. This bolt is used where heavy tension or lengthwise stresses must be sustained.

Clevis. The clevis bolt is a special-purpose bolt for use where shearing or sidewise stress occurs. Clevis bolts are never used for tension, but are

often used as pins in control systems. Clevis bolts are available with either slotted (for screwdriver) or recessed heads.

Eyebolt. The eyebolt is a special-purpose bolt used where external tension loads are applied. The eye is for attaching a turnbuckle fork, clevis, shackle, or tiedown rope.

Internal wrenching. This bolt is made of high-strength steel and is used primarily in high-tension applications. The head is recessed for internal wrenching.

Stud. The stud is used where a standard-type bolt is impractical, such as the mounting of engine accessories. One end of the stud has finer threads than the other end. The nut is put on the end with the fine threads.

Aircraft Nuts, Washers, and Screws. Since most types of bolts require a nut, let's look for a moment at the bolt's companion.

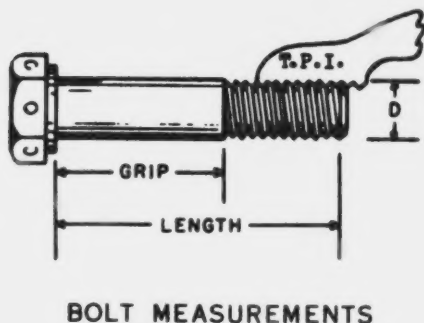
Nuts. Like bolts, nuts come in a wide variety of shapes and sizes. Aircraft nuts are not usually issued with the bolts and are identified by color of metal and construction (style, size, etc.). Nuts may be marked; however, you will find many nuts not marked at all (small self-locking, castellated, and others). Except for a few very special types, nearly all nuts are standard and can be divided into general groups: non-self-locking and self-locking.

Non-self-locking nuts must be safetied by external locking devices, such as locknuts, cotter pins, or safety wire. Some common types of non-self-locking nuts are plain castellated, castellated shear, and wingnuts. (See figure 2-42.)

Self-locking nuts, of course, lock themselves; the locking feature is built into the nut. They are designed to withstand severe vibration and are used to attach antifriction bearings and control pulleys, accessories, anchor nuts around inspection holes, etc. Self-locking nuts are not used at joints in control systems of aircraft where the movement of the joint would cause the nut to rotate against the surface on which the nut is bearing. At least 2 threads must extend through a self-locking nut for maximum locking effect.

Washers. Although there are many kinds of special-purpose washers, most washers used are either plain or lock. Plain washers are normally used under AN hexnuts to provide a smooth bearing surface and to line up the slots of castellated nuts with the drilled cotter pin holes in the bolts. Lockwashers are used with screws and bolts whenever the self-locking or castellated type of nut is not used. (See figure 2-43.) The spring action of the washer provides friction to prevent loosening of the nut from vibration.

Screws. The screw is a common form of a threaded securing device. It is usually described according to the shape of its head. Screws are made of steel, aluminum alloy, or brass, depending upon their use. Most screws can be obtained with



BOLT MEASUREMENTS

42-1815

Figure 2-41. Bolt dimensions.

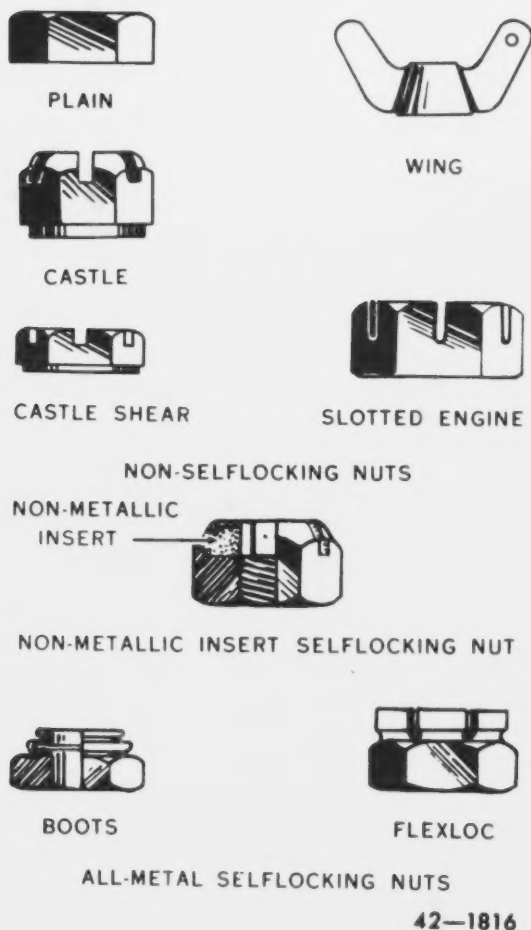


Figure 2-42. Non-self-locking and self-locking nuts.

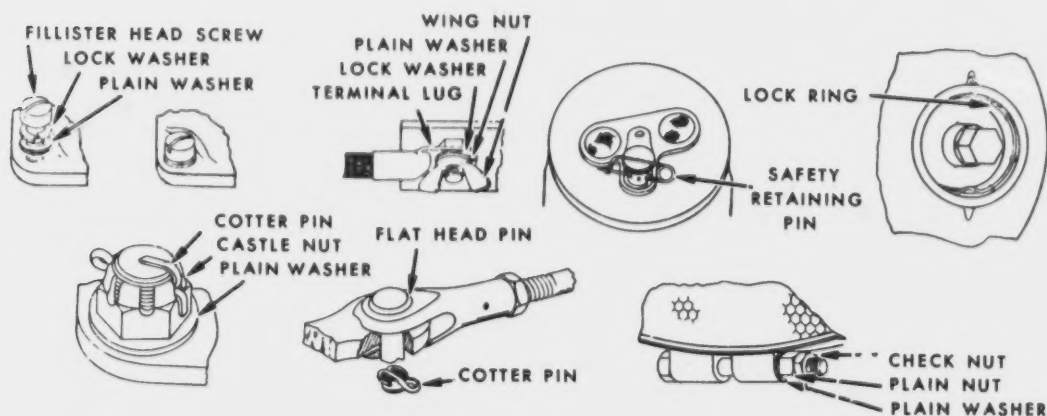


Figure 2-43. Safetizing devices.

different types of driving slots. They may be either slotted or cross slotted. Head styles vary according to use of the screws. Some of the styles are roundhead, buttonhead, fillister-head (slotted, cylindrical, and flat), flathead, and washerhead.

Securing Devices. To prevent bolts, nuts, and screws from loosening and falling off many securing devices have been made. Some of these are listed below.

Cotter pins. Cotter pins are used to secure various units, such as castle nuts, clevis pins, bolts, screws, and pins. The cotter pin is shown in figure 2-43. Always replace old pins with new pins of the same size. Pins should fit holes snugly and be bent as shown in figure 2-43. When removing a cotter pin, straighten the prongs. Then remove it with a cotter pin extractor or diagonal pliers. Remember, cotter pins should never be reused.

Safety pin. The safety retaining pin is used to lock such components as reservoir caps and lockpins. The pin locks either a screw or a unit to a housing. The safety pin prevents the unit or screw from turning or moving from its respective position.

Lockring. The lockring is used to hold end plates or retaining plates in their respective housing. This is done by installing the lockring in a groove after the end plate or retaining plate has been installed. It is held in the groove by its own spring tension. The correct lockring should fill its groove but can be rotated easily. These last three safetizing devices are shown in figure 2-43.

1. What do bolthead markings indicate?

2. Generally speaking, how should a bolt be installed?
3. What is a hexhead bolt used for?
4. What type of bolt is used when turnbuckle needs to be attached?
5. List two requirements to be followed when using cotter pins.
6. What type of nut must be used with external locking devices?
7. How many threads must extend through a self-locking nut?
8. Specify how a lockring should be installed.

231. Specify the safetying wire procedures commonly used on the flight line, and specify characteristics and restrictions applicable to each.

An experienced mechanic can tell you of various instances of aircraft systems failing due to loose nuts or bolts which can cause components to become misaligned or out of adjustment. Only too

often the culprit is due to aircraft vibration. Throughout the years strides have been made to reduce aircraft vibration and its effect. Since it is impossible to eliminate vibration altogether, certain safetying devices are used to prevent components from becoming loose.

Safety Wire. Safety wire comes in various sizes and material. Listed below are the most common types used.

0.020"	Steel
0.020"	Copper
0.032"	Steel
0.041"	Steel

The units to be safetyed will determine safety wire size and the method to use. But remember to always use new wire; never old wire. The two methods that are used are called the double-twist and single-twist methods.

Double-twist method. This may be done either by hand or with safety wire pliers. (See figures 2-44.) The wire is twisted so that the loop around the bolthead or nut stays down and should oppose any loosening up of the part. Be extremely careful when twisting the wire to insure that it is tight, but not to the point where it might break under a slight load or vibration. These should be about 8-10 twists per inch. Make a pigtail of $\frac{1}{4}$ to $\frac{1}{2}$ inch (3 to 6 twists) at the end of the wire. Bend the pigtail back or under to prevent it from becoming a snag and injuring personnel.

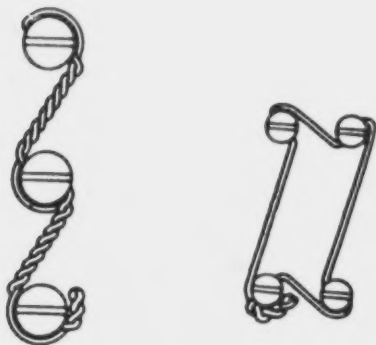
When securing widely spaced bolts by the double-twist method, wire no more than three bolts in a series. When securing closely spaced bolts, wire no more in a series than you can secure with a 24-inch length of wire.

When using the double-twist method of safety wiring, use wire of 0.020-inch diameter where safety holes have diameters of 0.045 inch or less. For holes larger than 0.045 inch, the diameter of the wire used should be about three-fourths the diameter of the hole. Start with 0.032-inch-diameter safety wire, working up until the right size wire is obtained.

Single-wire method. The single-wire method of safety wiring is like threading a needle through a button. Arrange the wire in such a manner that if a bolt, screw, or other threaded item begins to loosen, force will be applied in the direction that tightens the wire. (See figure 2-44.)

The single-wire method is used on close geometrical patterns, such as triangles, squares, rectangles, or circles, as well as in places difficult to reach. When using the single-wire method of safetying, use the largest size of wire that the safety wire hole will accommodate.

Electrical connectors (cannon plugs) should be safety wired with 0.020 steel wire only. Larger safety wire can break out the hole in the electrical



42-1853

Figure 2-44. Safetying with safety wire.

connector. See figure 2-45 for safety wire installation.

Shear wire. Wire is used where it is necessary to purposely break or shear the wire to permit operation of emergency devices. Notice the switch cover in figure 2-46. In order to position the switch, the wire will have to be broken first before the switch cover can be listed. Shear wire is usually 0.020-inch-diameter copper wire. For further information on safety wiring, refer to TO 1-1A-8 and 1-1A-14.

Exercises (231):

1. What safety wire methods do we commonly use?
2. What should be done with the pigtail and the double-twist method and why?
3. When is the single-wire method of safety wiring used?
4. When safetying closely spaced bolts by the double-twist method, how many are allowed to be secured?
5. What size wire is used in the double-twist method if the safety wire hole is less than 0.045 inch in diameter?

6. What size wire is used to safety wire electrical connectors?

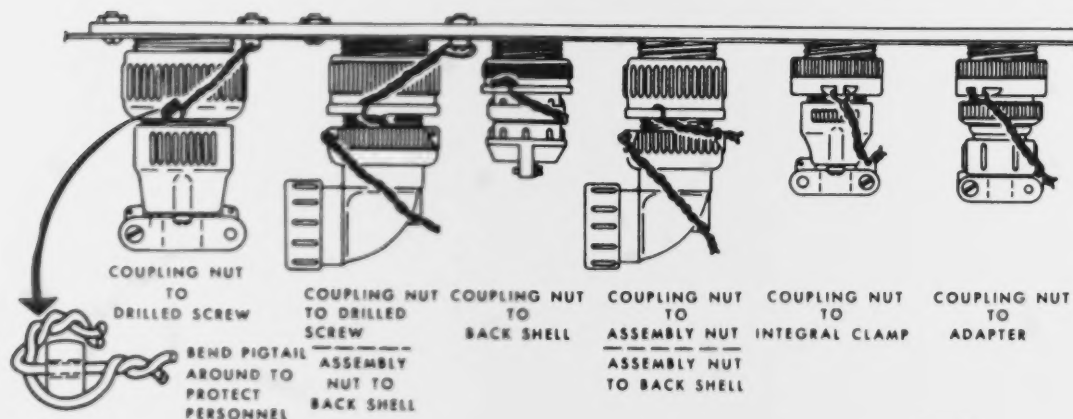
232. State the characteristics of aircraft cables, then describe the safety wiring process in relation to a cable adjusting component (turnbuckle).

Cables. Cables are used in aircraft to operate flight equipment and various control mechanisms. Control cables must be flexible throughout their length to operate aileron, elevators, rudders, etc. Regardless of the construction features of a cable, its size is always determined by diameter. Flexibility is determined by the number of strands in a cable plus the number of wires in a strand. Wires are wound around each other to form a strand. Individual strands are wound around one central strand to form a cable. Figure 2-47 is an example of two different types of flexible cables. A 7 x 7 cable has seven strands with seven wires per strand. A 7 x 19 cable is constructed of seven strands, with 19 wires per strand.

At regular inspection periods, cables should be inspected for broken wires by passing a cloth along the length of the cable. Broken wires are indicated where cloth is snagged.

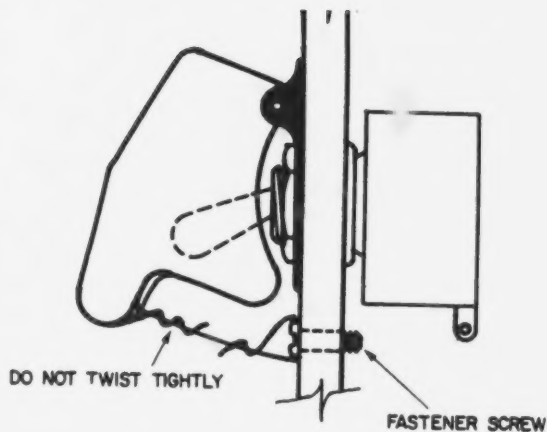
Turnbuckles. The turnbuckle is a device used to adjust the tension on aircraft cables. It consists of a brass barrel with right-hand threads on one end, and left-hand threads on the other. Left-hand threads can be identified by a groove or knurl on the end of the barrel. Three types of turnbuckle terminals are fork, pin eye, and cable eye.

Turning the barrel one way will tighten both ends and the other way will loosen both ends. It is essential that turnbuckle terminals be screwed into the barrel so that no more than three threads on



42-1525

Figure 2-45. Safetying electrical connections.



42-1548

Figure 2-46. Using shear wire.

each terminal are exposed. This prevents the threads from being stripped out.

To keep the terminals from vibrating loose from the barrel, some method of securing them must be used. Some turnbuckles are safetied with safety clips rather than by safety wire. We cover only the safety wire method (see figure 2-48). To safety wire turnbuckles, use the following steps (these are for general information, you must use the technical order on the job).

Step 1. Cut two sections of wire, each measured a length equal to three times the distance from terminal hole to terminal hole.

Step 2. Insert the first wire through the hole in the barrel until approximately half the wire is on each side, then bend in opposite directions. Insert the bottom wire end through the hole in the terminal.

Step 3. Insert the second wire through the barrel and bend in opposite directions to the first wire. Insert the second wire and (bottom) through the other terminal hole.

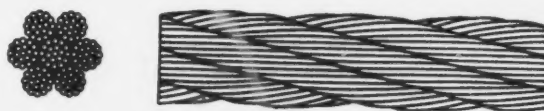
Step 4. Grasp both wires on one end and bend the wires back toward the barrel.

Step 5. Wrap each wire four complete turns or wraps.

Step 6. Complete the other side the same as the first. Push the cut wire ends tight against other wraps to eliminate the safety hazard of snags.

Exercises (232):

1. What cable characteristic is used to determine cable size?
2. A 7 x 19 cable is constructed of _____ strands each having 19 _____.
3. What is the simple way of determining if a cable has broken strands?
4. What is the purpose of the turnbuckle used on an aircraft?

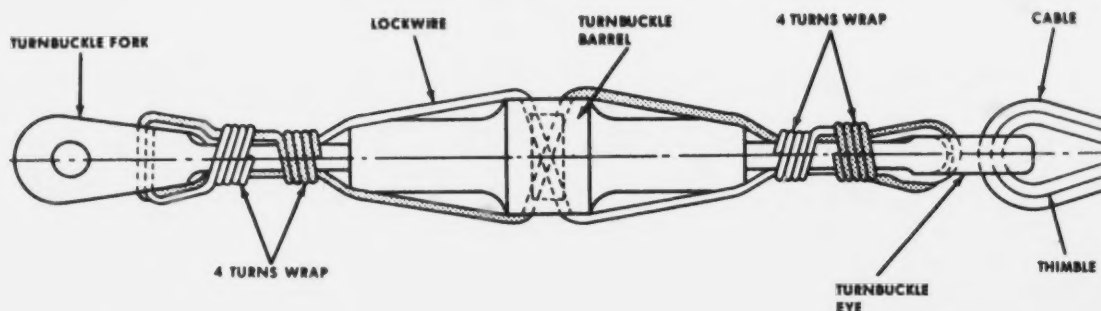


1. EXTRA FLEXIBLE CABLE - 7 X 19 (7 STRANDS, 19 WIRES PER STRAND)



2. FLEXIBLE CABLE - 7 X 7 (7 STRANDS, 7 WIRES PER STRAND)

Figure 2-47. Flexible cable.



42-1814

Figure 2-48. Safetying a turnbuckle.

5. How are left-hand threads identified on a turnbuckle?
6. What would be the maximum number of threads that may show between a terminal end and the barrel of a turnbuckle?
7. What are the minimum number of twists or wraps of safety wire used on the turnbuckle?

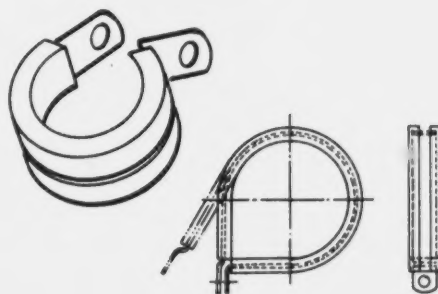
233. Specify the need and installation requirements for clamps on tubing and hose.

Clamps. Clamps are used to properly support rigid tubing and hose subject to vibration. Although it doesn't seem very important, clamps improperly installed, wrong size, or in some instances left off completely have led to severe aircraft accidents. An example is a recent aircraft incident that caused a fire and gear up landing. The accident investigation revealed that a hydraulic pump scavenge line, and an adjacent electrical harness had chafed each other. The chafing resulted in a hole in the hydraulic line. Arcing from the harness ignited the leaking hydraulic fluid. If these items had been properly routed and clamped, this could have been prevented.

Types of clamps. Two basic types of support clamps are used, the rubber cushioned and Teflon cushioned. The rubber-cushioned clamp shown in figure 2-49 gives excellent cushioning against vibration, but can be torn easily and is not compatible with certain fluids. The Teflon-

cushioned clamp is used in areas where the deteriorating effect of certain chemicals or other substances are expected. However, because it is harder, it does not provide as good a vibration-damping effect as the rubber clamp.

Clamp installation. One of the main things to remember when using clamps is to use the proper clamp. Make certain that clamps are of the correct size. You can find the correct size by using the aircraft -4 technical order. As an example, a clamp smaller than the outside diameter of a hydraulic hose may be extremely hard to install. If the clamp is too large, it will NOT support the tubing or hose properly. Another thing to remember about clamps is, place them according to the aircraft technical order. All plumbing lines must be secured at specified intervals. When tubing is connected to a structure or other rigid member, a minimum clearance of 1/16 inch should be maintained.



SUPPORT CLAMPS (CUSHIONED)

Figure 2-49. Clamp.

Exercises (233):

1. You are installing a hydraulic line on an aircraft and notice that a few of the clamps were broken or missing. What would you do?
2. Why should clamps be installed on tubing and hose?
3. Give advantages and disadvantages of the rubber clamp.
4. What would happen if a clamp larger than the outside diameter of a hydraulic hose was installed on the hose?

Maintenance Tools

FOR WANT OF A nail, a shoe was lost; for want of a shoe, a horse was lost; for want of a horse, the battle was—oh well, you know that story. It's been handed down through the years, and since no one has contested it, it's been accepted as fact. But the tale has been retold so many times that it's just possible the facts got garbled somewhere en route.

Maybe the battle was lost for the lack of a proper tool to drive the nail to fasten the horse's shoe. There were probably kegs and kegs full of nails at the local battlefield blacksmith shop. But the right tool for the job was important in those days too. Maybe the battle was lost because that tool wasn't used at the critical time.

Since the days when horses trod the battlefield, the proper use of handtools has grown even more important. For example, the maintenance of modern aircraft absolutely demands that the correct tool for the job be used—and used correctly. When the wrong tool is used, or when the right tool is used incorrectly, serious accidents can result. Some mechanics think that handtools are so simple that no one needs to bother about pointing out the right and wrong way of using them.

Nevertheless, the proper care, handling, and use of basic handtools, measuring tools, and special tools are outlined in this chapter. If the subject matter in this chapter is studied with an open mind, it should pay dividends for both the specialist and the Air Force.

3-1. Common Handtools

In man's very earliest days, there was no civilization as we know it today. Gradually, man learned to make his life easier. He learned how to make more comfortable and more beautiful surroundings for himself by experimenting with the materials that nature supplied. As extensions of his hands and his ever-growing intellect, man fashioned tools from tree climbs and chips of stone. It was from these first crude tools, improved and refined over a period of time, that our present technology evolved. Just as tools were very important to man in the early stages of civilization, man's tools of today (from the simple to the highly complex)

provide the impetus for continually advancing the knowledge of man.

234. List the three basic types of hammers; and given a list of different hammers, match the proper hammer with the job.

Hammers. Hammers are classified as common hammers, soft hammers, and sledges. (See figure 3-1.) Each type has its own special use. We will talk about the two hammers most often found in the mechanics toolbox, common and soft.

There are many kinds of common hammers, but the one most widely used is the ball peen. Ball peen hammers are classified according to the weight of the hammer head without the handle. They are available in weights ranging from 2 ounces to 2 1/2 pounds. The lighter hammers obviously are used for light work; the 2 1/2-pound ball peen hammer is used for heavy work.



Figure 3-1. Commonly used hammers.

Some repairmen have a tendency to "choke" the hammer by gripping the handle close to the head. When the hammer is held this way, the force of the blow is greatly reduced and it is harder to hold the head in the proper position. If you have the habit of choking the handle, try gripping it close to the end where it is shaped to fit your hand. Then you can use the hammer in the manner intended. The face of the hammer head, shown in figure 3-2, is slightly convex. The outside edge is rounded to eliminate a sharp edge that would mar the object being driven if it were struck at a right angle.

When you strike a blow, use your elbow as a pivot point and not your wrist. If you use your forearm as an extension of the handle, the blow will be more effective. You will have a better chance to strike squarely because the radius of your swing is longer. The object should be struck fully with the face of the hammer, with the hammer face parallel to the work, as illustrated in figure 3-2. This method of striking spreads the face of the blow over a greater area and avoids damaging the edge of the hammer face. Correct use of the hammer transmits the force of the blow to the object being driven without damage to the object or the hammer.

The hammer handle should always be tight in the head. If the handle is loose, don't use the hammer: the head may fly off and cause a serious injury. The eye, or hole, in the hammerhead, shown in figure 3-2, is made with a slight taper in both directions from the center. After a handle is inserted in the head, a steel wedge is driven into the end of the handle, expanding it in the outer tapered portion of the eye. Thus, the handle is wedged in both directions. If the wedge starts to come out, remove it and drive in a slightly larger wedge.

In addition to the ball peen hammer, your toolbox includes soft-face hammers (mallets). The

mallet head may be made of a single soft material, or may be combined with other materials to add weight. The material used may be plastic, rubber, rawhide, brass, or lead. Like hammers, mallets are made in several convenient sizes, the most common weighing between 6 ounces and 2 pounds. A mechanic uses a mallet for the same purpose that he uses a hammer—to strike an object so that it will move. But sometimes he cannot use a hammer because the hard steel of the hammer would dent, crack, or otherwise damage the object being struck. In such instance, he uses a mallet because the mallet's soft face will "give" with the blow instead of damaging the object. In fact, you should never use a hard-face hammer on machined polished surfaces unless you use a piece of soft brass, copper, lead, hardwood or similar object between the surface and the hammer.

Exercises (234):

1. List the three basic types of hammers.
2. Match the proper hammer in column B with the job in column A. Column B entries may be used more than once.

Column A	Column B
— a. For installing bearings in a strut.	(1) Ball peen
— b. For installing attaching bolts for an actuating cylinder.	(2) Soft-face hammer (mallet)
— c. For removing a gland nut from a strut with a brass rod.	

235. Specify the use of the various types of screwdrivers and state the precautions to take when reshaping a common screwdriver.

Screwdrivers. Screwdrivers are only for tightening or loosening screws. However, some people use them incorrectly as chisels, punches, putty knives, tire tools, wrecking bars, ignition or battery testers, can openers, ice picks, etc.

As shown in figure 3-3, a screwdriver has three main parts: the handle, the shank, and the blade. The ferrule (not shown) is used to secure the shank to the handle. Screwdrivers are sized by the length of the shank. The handle is usually made of wood or plastic and is designed as a grip. For this obvious reason, do not hammer or pound on the screwdriver handle. The thin steel shank can withstand considerable twisting, but it is likely to bend or crack if it is used as a pry or pinchbar. The tip of the blade is hardened to keep it from wearing, and the harder it is, the more easily it will

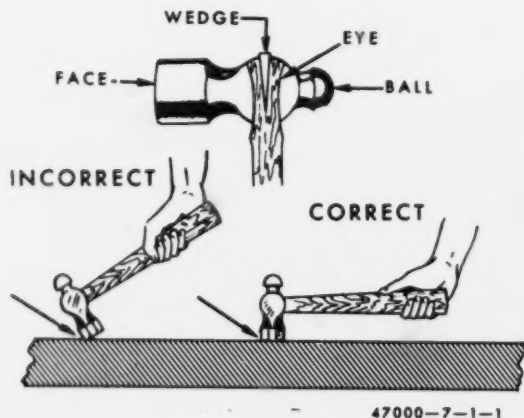


Figure 3-2. Use of hammer.

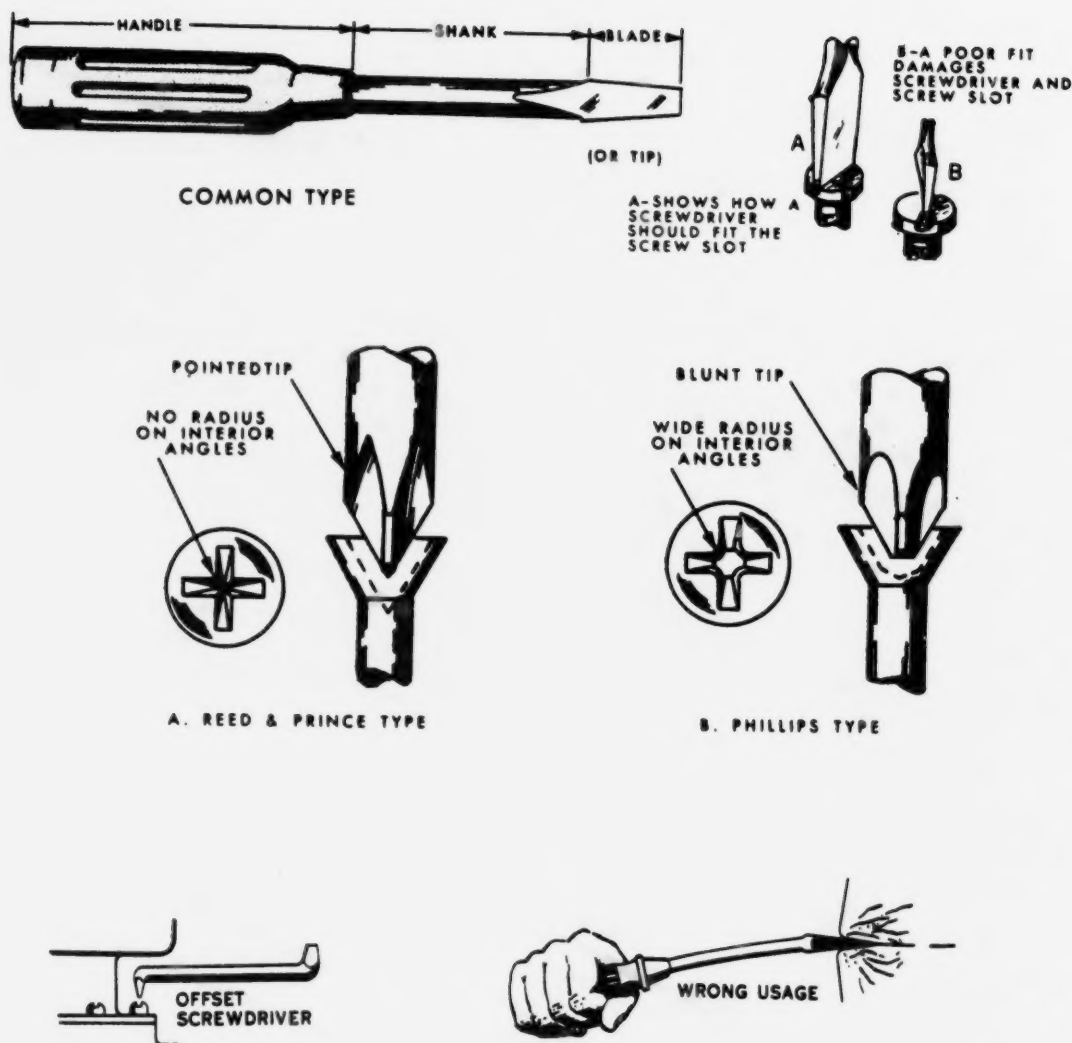


Figure 3-3. Screwdriver uses.

break if much bending strain is applied. If the shank of a screwdriver is bent, it is usually very difficult to straighten, and you will have trouble keeping the screwdriver in the center of the screw slot.

The most common types of screwdrivers are the standard (flat-blade), offset, and cross-point. Figure 3-3 shows all three types. The common flat-blade screwdriver is available in many sizes and is the most frequently used.

There cannot be enough emphasis placed on selecting the correct screwdriver size so that the blade fits snugly into the screw slot. Figure 3-3 shows both a right and a wrong screwdriver fit. A good fit prevents the screw slot from becoming burred or the blade from being damaged. It also

reduces the force needed to keep the blade in the slot. If a screwdriver does not fit completely into the slot, the screwdriver is likely to slip and punch holes into the material around the screw. Even though you are using a screwdriver that fits correctly, never hold the work in your hand when you are tightening or loosening a screw. If the screwdriver should slip out of the screw slot (as it can), you might get stabbed in the palm of your hand.

How many times have you reached for a screwdriver and found one with a broken blade? You probably have one now in the bottom of your toolbox or in your work area. If the blade isn't too badly broken, it can be ground on an emery wheel and made serviceable again. The tip of the blade

should be ground to make the end square and flat, and the sides practically parallel. The blade sides should gradually taper out of the shank body. When you are grinding the screwdriver on the emery wheel, use a light pressure and do not overheat the metal, because overheating removes the temper. Remove as little metal as possible so that you do not grind beyond the hardened area of the blade tip.

The offset screwdriver is a handy tool in tight places. One blade is forged in line with the handle or shank, and the other end is at right angles to the handle, as shown in figure 3-3. This screwdriver is used when there isn't enough room to use a standard screwdriver.

Cross-point screwdrivers are made with specially shaped blades or bits that fit cross-recessed screws, as shown in figure 3-3. This type of screwhead checks the tendency of the screwdriver tip to slip out of the recess and damage the surface of the work. Cross-point screwdrivers come in a variety of sizes, and as with the other types, you must take care to use the correct size for the screw you want to loosen or tighten. It is very easy to burr a cross-recessed screw and thus render it impossible to loosen.

Exercises (235):

1. What should screwdrivers be used for?
2. How do you know whether you are using a screwdriver that is the right size?
3. What precautions must you take when using an emery wheel to reshape a standard common screwdriver?
4. What type of screwdriver should you use if there is not enough room to use a standard screwdriver?
5. What type of screwdriver is used for cross-recessed screws?

236. Specify the various uses and characteristics of specific types of pliers.

Pliers. Pliers rank close to screwdrivers as being the most misused handtool. No tool in your box can

ruin more work than a pair of pliers. You have probably seen pliers used for everything from a pry bar to a pipe wrench. Pliers are usually designed to serve only a few purposes: to hold or grip small material, to cut small soft wire, or to bend light metal or wire into a desired shape. Pliers should never be used in place of a wrench to tighten or loosen nuts or bolts. A man who does so indicates that he is a poor mechanic. Think of a pair of pliers as a holding tool, never as a tightening tool.

Slip-joint pliers. These are also called common or combination pliers. These are shown in figure 3-4. Combination pliers come in 5-, 6-, 8-, and 10-inch sizes (the length of the handle determines the size). Some are made with a side cutter arrangement for snapping cotter pins. The slip joint allows the jaws to open wider at the hinges for gripping larger material. These pliers are used principally for holding or bending flat or round stock.

Diagonal (dike) pliers. Use diagonals figure 3-4 for clipping cotter pins, pulling cotter pins from castellated nuts, for spreading split ends of cotter pins, and also to cut small wire. These pliers are sturdy, but are not designed to cut bolts, rivets, or hard steel; neither are they designed to serve as tin snips. If and when you do cut material with your "dikes," use the back, or throat, of the jaws, not the



COMBINATION SLIP JOINT



DIAGONAL CUTTING



WATER PUMP



VICE GRIP

47-230

Figure 3-4. Types of pliers.

point. Using the point in cutting may spring the jaws. Once the jaws are sprung, it is difficult, if not impossible to cut fine wire with them.

Adjustable water pump pliers. These pliers, shown in figure 3-4, are similar to the standard combination pliers except that the jaws are offset. In comparison with combination pliers of equal length, more leverage can be applied to the jaws of the water pump pliers. Water pump pliers were originally designed for tightening water pump packing glands, but have since become a general-purpose tool. Unlike combination pliers, water pump pliers have five instead of two adjustments to the jaws. This feature makes them a handy tool for gripping odd-shaped objects and hard-to-reach objects when no other tool is available. However, do not use these pliers in place of a wrench.

Vise grip pliers. These pliers, shown in figure 3-4, have a locking device on the movable jaw. The jaws are adjustable to openings of various sizes, and automatically lock in position when the handles are closed. This tool is used primarily to hold parts securely while you are working on them.

Duckbill pliers. Duckbill pliers, as shown in figure 3-5, (A), have long wide jaws and slender handles. Duckbills are used in confined areas where the fingers cannot be used. The jaw faces of the pliers are scored to aid in holding an item securely. Duckbills are suitable for twisting the safety wire used in securing bolts, nuts, and screws if wire twisting pliers are not available or cannot be used.

Needle-nose pliers. Needle-nose pliers (figure 3-5, (B)) are used in the same manner as duckbill pliers. However, there is a difference in the design of the jaws. Needle-nose jaws are tapered to a point, which makes them adapted to installing and removing objects in tight places, and for making delicate adjustments. They have serrations at the

nose end and a side cutter near the throat. This allows them to cut and bend safety wire also.

Wire-twister pliers. Wire twisters (safety wire pliers) are three-way pliers which can hold, twist, and cut. (See figure 3-5, (C).) They are designed to reduce the time used in twisting safety wire. To insure proper operation of the wire-twisters, the spiral of the twister should be lubricated occasionally.

Snapping pliers. Snapping pliers come in several different sizes, both inside and outside type; that is, they are designed either to spread snaprings or to clamp them together. Figure 3-6 shows a pair of snapping pliers, with a snapping.

Care of Pliers. Pliers, like other tools, should be kept clean. Give them an occasional bath in an approved cleaning solvent in order to wash off the dirt and grit. Also, give the joint pin an occasional drop of oil.

Exercises (236):

1. What are pliers designed to do?
2. Which pliers have a locking device on the movable jaw?
3. Match the correct action in column B with the jobs in column A.

Column A

- a. — Gripping odd-shaped objects.
- b. — Cutting small wire.
- c. — Loosening nuts.
- d. — Making delicate adjustments.
- e. — Holding parts securely while you are working on them.
- f. — Cutting bolts or screws.
- g. — Twisting wire.
- h. — Tightening bolts.
- i. — Replacing cotter pins.

Column B

- (1) Do not use pliers; use another type of tool.
- (2) Use adjustable water pump pliers.
- (3) Use vise grip pliers.
- (4) Use diagonal cutting pliers.
- (5) Use needle-nose or duckbill pliers.
- (6) Use wire twisters.

237. Specify the proper use(s) of various wrenches.

Wrenches. A good mechanic does not use pliers on hardened surfaces, because he knows that this would dull the teeth of the pliers and cause them to lose their grip. Neither does he use pliers to loosen or tighten nuts, because this would round off the corners of the nuts. Instead, he uses one of the wrenches we shall now discuss.

Wrenches are tools designed for exerting a twisting strain, as in turning nuts or bolts. Most nuts and bolt heads have six sides. A wrench is

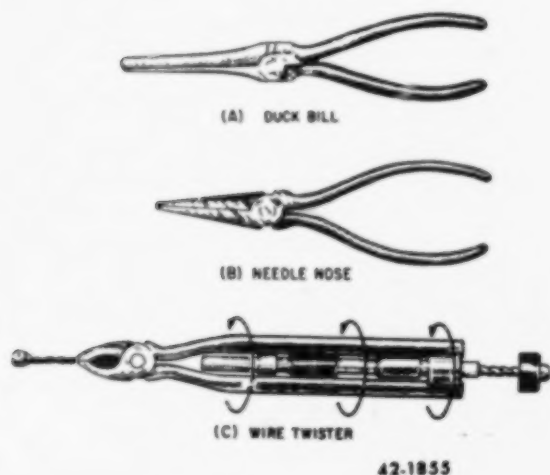


Figure 3-5. Duckbill, needle-nose and safety wire pliers.

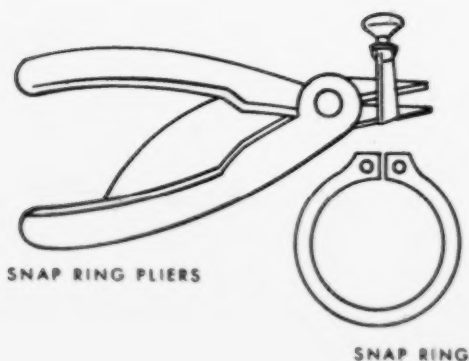


Figure 3-6. Snapping pliers.

designed to fit the sides or flats of these nuts or heads. In using a wrench, you should always pull—never push. Pushing on a wrench is dangerous. If you push on a wrench to loosen or tighten a nut, and the nut suddenly breaks loose, you will invariably strike your knuckles on some part of the unit on which you are working. If you must push, use the base or palm of your hand and hold your hand open; this hand position may save your knuckles from cuts and bruises.

The wrenches you will be using are probably made of chromium-vanadium steel. It is almost impossible to spring or break any of these wrenches if you use them properly. The most common types of wrenches you will use are the adjustable-jaw, the open-end, the box-end, and the socket.

Adjustable-jaw wrenches. The adjustable-jaw wrench, shown in figure 3-7, has a movable or adjustable jaw. The length of the handle determines the size of the wrench. Thus, a 6-inch adjustable wrench has a 6-inch handle, although its jaws open only to $\frac{3}{4}$ inch. Adjustable wrenches with longer handles have larger jaw openings.

The adjustable wrench is not intended to take the place of open-end, box-end, or socket wrenches. It is to be used only on an odd-size nut or bolthead that none of your other wrenches will fit properly.

Adjustable wrenches will not stand excessive strain, especially at the wide open position. If you need to exert force on an adjustable wrench to "break loose" a tight nut, or to "snug down" a nut you are tightening, there are two important points to remember. First, always place the wrench on the nut so that the pulling force is applied to the stationary jaw. Second, after placing the wrench on the nut, tighten the wrench so the jaws fit the nut snugly. If you do not observe these two points, you are likely to spring or break the wrench on a hard pull.

Under no circumstances should you ever hammer on the handle of an adjustable wrench to loosen or tighten a nut. Also, you should not use an

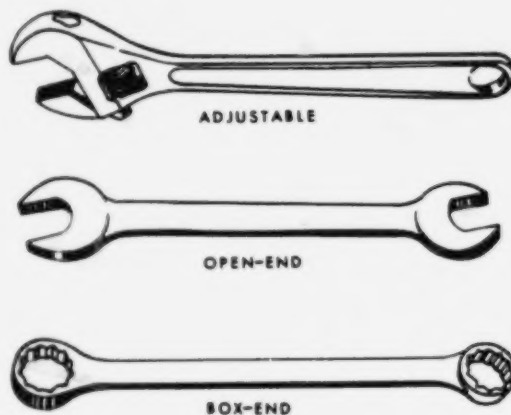
extension on the handle to get more leverage.

Open-end wrenches. Wrenches with an opening in each end, shown in figure 3-7, are called open-end wrenches. The size of the openings between the jaws determines the size of the wrench. The measurements refer to the distance between the jaws of the wrench, or across the flat of the nut or bolthead; they do not refer to the diameter of the bolt. If you measure the openings of your wrenches, you will find that they measure from 0.005 to 0.015 inch larger than the sizes marked on them. This small difference makes it easier to slip the wrench on and off boltheads and nuts.

The smaller the openings in the wrench, the shorter its overall length. This proportions the lever advantage of the wrench to the size of the nut or bolt. For a given amount of pull on a wrench, a shorter length produces less twisting or torque, and reduces the possibility of stripping the threads.

The heads and openings of open-end wrenches are at an angle to the handle. Most are designed with a 15° offset, while some are designed with as much as a 90° offset for special purposes. Wrenches with such special offsets permit working in close quarters. Turning the wrench over after each stroke reverses the angle of the head. The 15° angle of the jaw, plus the turning over of the wrench, enables you to continue turning a hexagonal nut even when the swing of the wrench is limited.

Box-end wrenches. One of the features of the box-end wrench, shown in figure 3-7, is that it can be used in close quarters. These wrenches are called box-end wrenches because they completely box (or surround) the nut or bolthead. Thus, they aren't likely to slip. The wrench has 12 notches (or points) arranged in a circle. A 12-point wrench can be used to loosen or tighten a nut where the minimum handle travel is 30° . These wrenches are ideal on



47-231

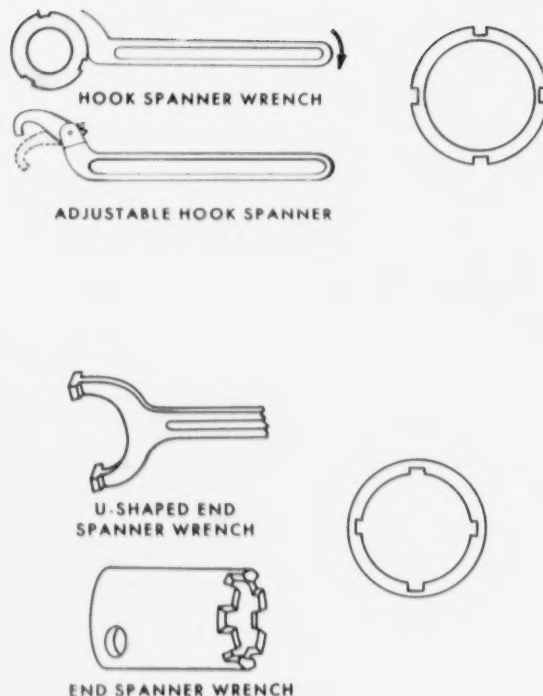
Figure 3-7. Types of wrenches.

exposed nuts where they can be turned or spun in a complete circle. Another advantage of these wrenches is that there is little or no danger of their slipping off a nut if they are placed properly. The disadvantage of using these wrenches as compared to open-end wrenches is that they are slower. After each partial turn, a box-end wrench must be lifted from the nut and repositioned for another turn. A box-end wrench can be used to good advantage to finish securing nuts that have been tightened with an open-end wrench.

Cutaway box-end wrench. Another version of the box-end wrench is the cutaway box-end wrench, also known as a tube wrench, shown in figure 3-8. This wrench is designed for tightening plumbing connections. The cutaway enables the box to be slipped over the tubing and then positioned on the nut of the connection. This type of wrench has an advantage over an open-end wrench when you are tightening tube connections. This is because there is little chance of the cutaway wrench slipping off the nut.

Strap wrenches. The strap wrench consists of a bar with a strap attached to one end. It is used to hold or turn cylindrical parts without damage to the surface. A strap wrench is shown in figure 3-9.

Spanner wrenches. Spanner wrenches are special wrenches for special jobs. There are a number of types, some of which are shown in figure 3-10. The



42-413

Figure 3-10. Spanner wrenches.

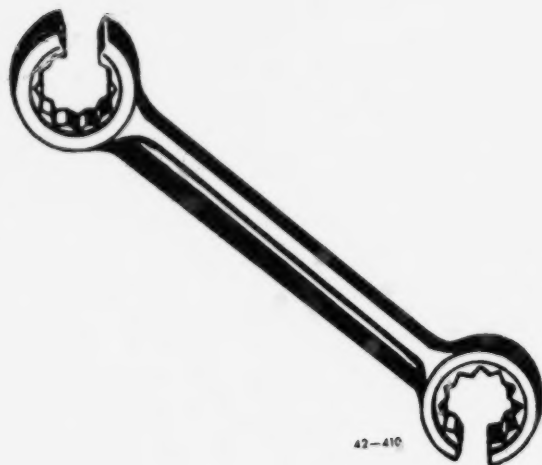


Figure 3-8. Cutaway box-end wrench.



Figure 3-9. Strap wrench.

hook spanner is for a round nut that has a series of notches cut in the outer edge. The hook or lug is placed in one of the notches with the handle pointing toward the direction in which the nut is to be turned. Some hook spanner wrenches are adjustable, and will fit nuts of various diameters. U-shaped hook spanners have two lugs on the face of the wrench to fit notches cut in the face of the nut or screwplug. End spanners resemble a socket wrench but have a series of lugs on the end that fit into corresponding notches in the nut or plug.

Socket wrenches. Because different handles can be used, the socket wrench is usually the strongest, safest, and fastest wrench in the toolkit. As shown in figure 3-11, there are many varieties of drives and adapters, such as extensions and universals, which permit the use of sockets in close quarters. The handle choices are the speed handle, the hinge handle, the sliding T-bar handle, and the ratchet handle.

Handles and extensions used on sockets are made in many different drive sizes to fit specific types of work. The most common sizes used by repairmen are $\frac{1}{4}$ -, $\frac{3}{8}$ -, $\frac{1}{2}$ -, and $\frac{3}{4}$ -inch drives. The drive size refers to the size of the end that fits in the socket. The $\frac{1}{4}$ -inch drive is used for very light work, and the $\frac{3}{4}$ -inch for very heavy work. In using these wrenches, you first loosen the nut or capscrew with

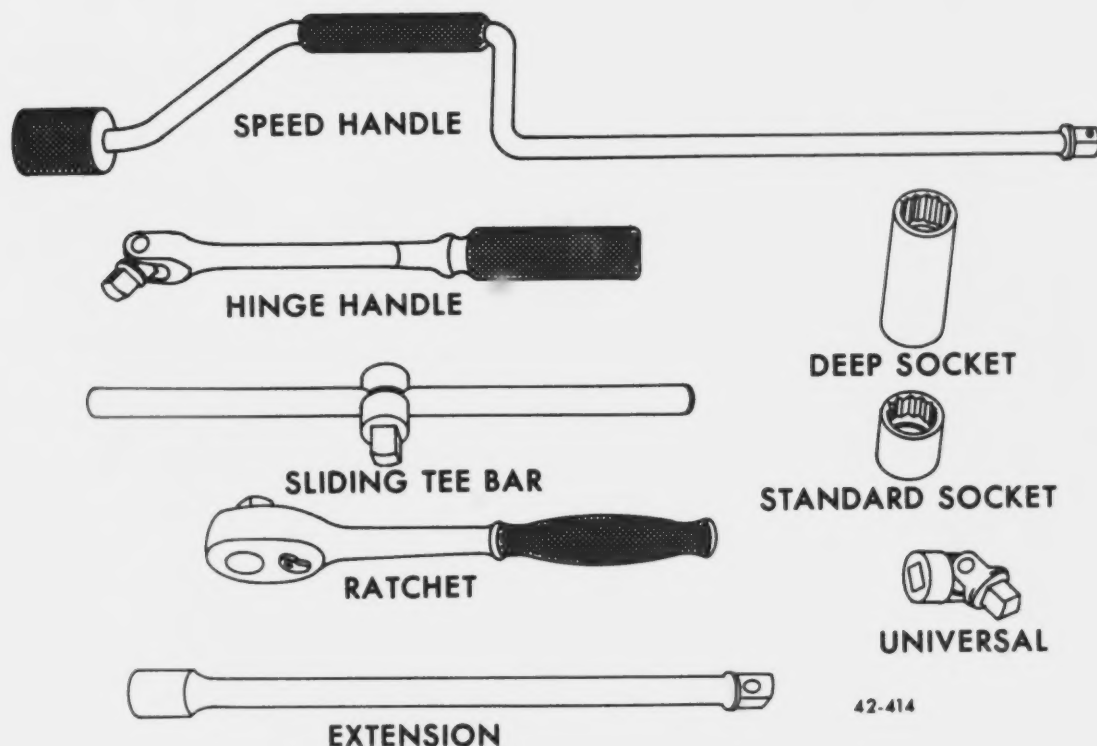


Figure 3-11. Socket wrenches.

the hinge handle, shown in figure 3-11. Then you use the speed handle. If close quarters prevent the use of the speed handle, the ratchet handle is used. Don't use the ratchet handle on heavy work, because it is not made for work requiring great strain. The last choice would be the sliding T-bar handle that is used in close or confined places.

Various lengths of extension bars, figure 3-11, are available. These are used with sockets to reach fasteners located in deep recesses. The extensions provide knuckle clearances over projecting objects. The deep socket, shown in figure 3-11, usually has thinner walls than the standard socket; both are available in a variety of sizes. The deep socket is used to reach recessed spark plugs, nuts, and studs on cylinders and other hard-to-get-to places.

A universal joint, shown in figure 3-11, can be used with many combinations of handles, extensions, and sockets to reach nuts and bolts at various angles. The universal joint is therefore very useful. With experience, you can work out any number of combinations for hard-to-reach places.

Allen wrenches. Another type of wrench you may sometimes have occasion to use is the Allen wrench. (See figure 3-12.) This wrench is a six-sided, L-shaped rod, and is designed to fit into the recessed head of a setscrew or capscrew. Either end

of one of these wrenches will fit into the recess, making it useful where either a long or short reach is desired.

Exercises (237):

1. In working with a socket wrench, should you use the speed handle to break nuts loose?
2. For what reason should you pull, rather than push, with a wrench?
3. For loosening and tightening odd-sizes nuts and bolts, the repairman should use what type of wrench?
4. Indicate whether the following uses of wrenches are proper by writing "yes" or "no" in the spaces provided.

- a. — Using an extension on the handle of an adjustable-jaw wrench in order to get more leverage.
- b. — Turning a box-end wrench in a complete circle to loosen an exposed nut.
- c. — Using an open-end wrench considerably larger than the bolthead to be turned.
- d. — Using a ratchet handle in the socket wrench for heavy work.
- e. — Applying the pulling force to the stationary jaw of the adjustable-jaw wrench.
- f. — Using an extension and a deep socket to reach recessed spark plugs.
- g. — Using the adjustable-jaw wrench as your "all-purpose" wrench.
- h. — Using a cutaway box-end wrench to tighten a plumbing connection.
- i. — Using a spanner wrench to break open a "B" nut.
- j. — Using a strap wrench to hold a fitting while tightening the "B" nut with an open end wrench.

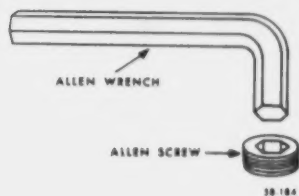
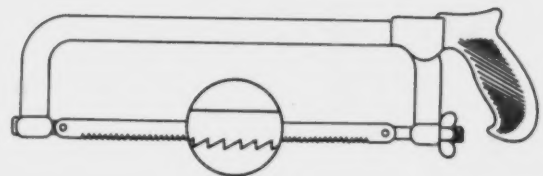
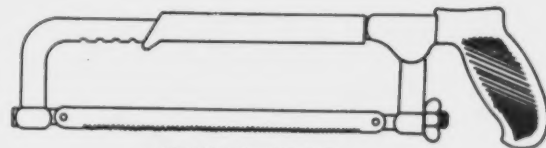


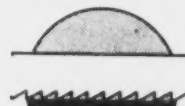
Figure 3-12. Allen wrenches.



SOLID FRAME



ADJUSTABLE FRAME

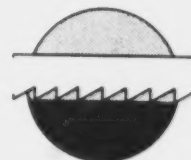


TEETH TOO SMALL
NO CHIP CLEARANCE
TEETH CLOG



TEETH TOO COARSE
STRADDLES WORK

WRONG



COARSE TEETH
AMPLE CHIP CLEARANCE



TWO OR MORE
TEETH ON METAL

RIGHT

42-418

Figure 3-13. Hacksaws and blades.

238. Specify the proper hacksaw blade to use for various jobs, then determine if given statements concerning the hacksaw's use are true or false.

Hacksaws. Hacksaws are used for cutting metal in much the same manner as a carpenter saw cuts wood. Most of the hacksaws have adjustable frames, figure 3-13, and hold blades ranging in length from 8 to 16 inches. The hacksaw frame is constructed so that the blade can be inserted either parallel or at right angles to the frame. A wingnut located on the end of the frame is used to draw the blade tight in the frame. If the blade is not drawn up tight, you will probably break it the first time you attempt to use the hacksaw.

Hacksaw blades are made of high-grade hardened and tempered tool steel. There are two types of blades, the all-hard and the flexible. The all-hard blades are hardened throughout, while only the teeth of the flexible blades are hardened. In selecting a hacksaw blade, you must decide upon the number of teeth and whether to use an all-hard or a flexible blade. An all-hard blade is best for sawing brass, tool steel, cast iron, and other stock with a heavy cross section. A flexible blade is best suited for sawing thin metal and tubing. The following recommendations should help you to determine the proper pitch (number of teeth) to use for a particular job.

a. Use a blade with 14 teeth per inch on machine steel and cold rolled steel. This coarse pitch makes the saw free and fast cutting.

b. Use a blade with 18 teeth per inch on solid stock, aluminum, brass, tool steel, cast iron, etc. This pitch is recommended for general use.

c. Use a blade with 24 teeth per inch on tubing, tin, brass, copper, channel iron, and sheet metal over 18 gauge. If a coarser pitch is used, the thin stock will tend to strip the teeth out of the blade and make it difficult to push the saw.

d. Use a blade with 32 teeth per inch on thin-walled tubing and conduit, and on sheet metal thinner than 18 gauge.

You should have two or more hacksaw teeth, as shown in figure 3-13, in contact with the metal being cut. This is the reason you must use a blade with 32 teeth per inch when you are cutting thin-walled tubing, conduit, and thin sheet stock. However, if this blade is used on larger pieces of metal, it will not provide enough chip clearance. In this case, the teeth become clogged and the blade may break. Before you start a hacksaw cut, check again to see that you have the proper blade. Also, make sure that the teeth point away from the handle, as shown in figure 3-13. Always tighten the adjustment so that the blade is rigid in the frame. If the material to be cut is not already anchored to something, secure it in a vise or with clamps. You must hold the material firmly to prevent the blade from chattering or twisting. If you nick the work with a file or cold chisel at the point where you desire to make your cut, the blade will start more easily.

Hold the hacksaw firmly, and move it forward with a light, steady stroke. Always use both hands, one gripping the handle and the other applying a slight pressure on the saw by gripping the point of the frame. At the end of the stroke, relieve the pressure and draw the saw straight back. After a few strokes, make each one as long as possible without striking the frame (or your knuckles) against the work. The most effective cutting speed is about 40 strokes per minute. Don't get in a hurry and try to speed up your cutting time. Such haste

often results in broken blades and skinned knuckles. If you saw too fast, the cutting action of the blade can generate enough heat to ruin its temper. In cutting hard metals, reduce the number of strokes per minute.

Exercises (238):

1. Specify the proper hacksaw blade pitch to use for specific jobs.

a. 20-gauge sheet metal.

b. Thin-walled tubing.

c. 16-gauge sheet metal.

d. Solid stock of aluminum or brass.

e. Tin.

2. Determine if the following statements are true or false concerning the use of a hacksaw. If the answer is false, explain why it is not true.

— a. The cutting teeth of a hacksaw should face toward the handle.

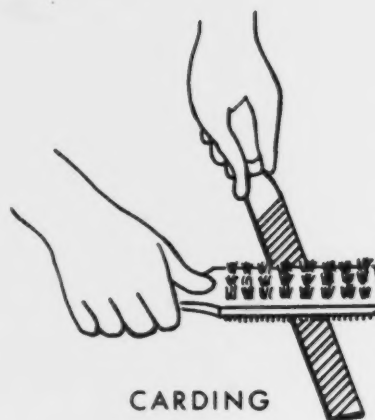
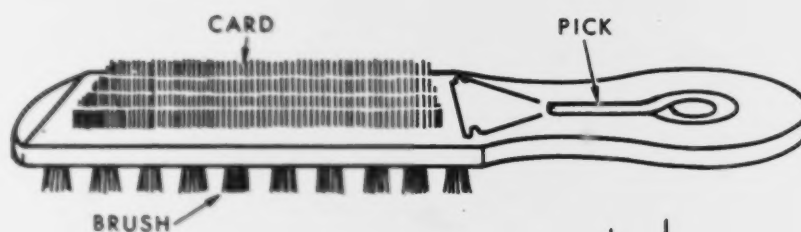
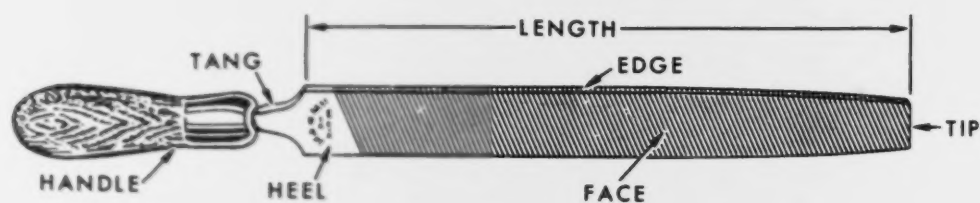
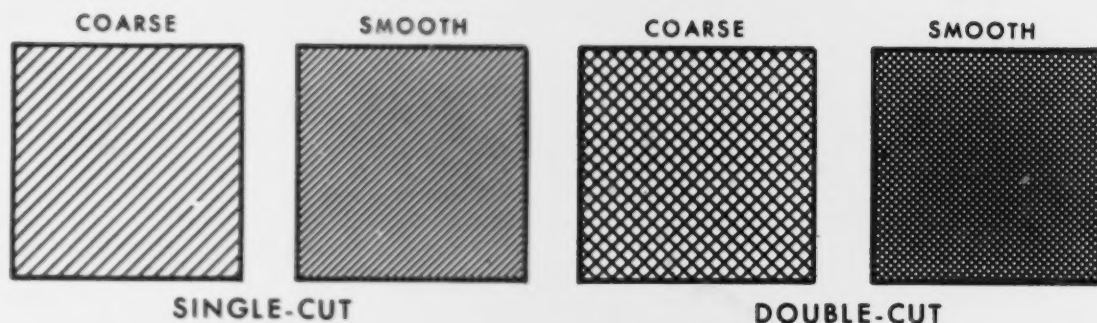
— b. The material to be cut should be anchored securely.

— c. You should use a smooth even pressure on both the fore and aft stroke.

— d. When cutting hard metals the speed of the cut should be increased.

239. Specify the constructional features of a file, cite the tool that is used to clean a file, then list at least three ways that a file can be damaged.

Files. Your toolkit should contain a small assortment of round, triangular, and flat files. Files



42-417

Figure 3-14. Files.

are hardened steel tooled for cutting, removing, smoothing, or polishing metal. The cutting edge (teeth) on file surfaces is made by parallel rows of sharp ridges. Files are classified as single-cut or double-cut, as illustrated in figure 3-14. Note that the classification depends on whether the ridges are cut in one or two directions. Files are also classified according to their coarseness. It is important that you select the correct file for the work you have to do. The following points will help you in your selection: Use a coarse file for soft metals and a smooth file for hard metals. The double-cut file gives a smoother cut, and will remove more material per stroke.

Files usually have a tang end that is tapered, smooth, and pointed. The purpose of such an end is for attaching a handle to it. A file with a tang should never be used without a handle, since the tang can cut into your hand. Be certain that the handle is fastened securely to the tang of the file.

Knowing how to use the file is as important as knowing which file to use. The correct way to hold a file is with the handle against the palm of one hand, thumb on top, and the end of the file in the other hand with the fingers curled under it. Don't take more than 30 to 40 strokes per minute: too much speed can ruin both the file and the work. Apply pressure on the forward stroke only. Lift the file from the work on the return stroke. Apply only enough pressure to make the file cut evenly. For filing round surfaces, use a rocking motion as you move the file across the work.

It is bad practice to bear down hard on a new file. When the file is new, the teeth are very sharp and dull quickly if you apply too much pressure. Hold the work firmly in a vise, with the surface to be filed projecting slightly above and parallel with the vise jaws. If work is loose in the vise, the file will clatter, damaging its teeth. Break in a new file by using it first on brass, bronze, or smooth cast iron. Do not break it on a narrow surface, such as sheet iron; the narrow edge is likely to break off the sharp points of the new teeth. Also, a new file should never be used to remove the scale on cast iron; remember that most of the damage to new files is caused from too much pressure during the first strokes.

Never use a file after the teeth become "choked" or clogged with particles of metal. To jar loose the filing, bump the tip of the file or the end of the handle on the bench every now and then while filing. This won't always get all the chips out, so the thing to do when the file gets "loaded" is to clean the teeth with a file card, as shown in figure 3-14. When you are cleaning a file, lay it flat on the bench and draw the file card and brush back and forth across the file parallel with the cuts. If there are any chips left after using the file card, these should be dug out with a pointed cleaning wire called a pick or scorer. Usually a file card has one

attached to the handle. Occasionally apply a light coat of oil to your files to prevent rust from forming.

Never use a file on a material harder than it is or on sandy or scaly castings. One stroke across such a surface can make the file useless. To prevent scratching when you are filing wrought iron, steel, or hard fiber, apply a little oil to the surface of the file to lubricate the chips. Like any cutting tool, a file is easily dulled by improper handling. Don't throw files in a drawer or box where they can rub against each other or against other tools. It is best to store them in separate holders such as clips, straps, or a wooden block with holes cut in it.

Exercises (239):

1. What is the name of the tool used to clean files?
2. What does the classification "double cut" mean?
3. Explain what type file should be used on hard and soft metals.
4. What is the tang of a file?
5. List at least three ways that a file can be damaged.

240. Specify the proper uses of various types of punches.

Punches. Figure 3-15 shows various kinds of punches; refer to this illustration as we discuss each kind. Starting punches, sometimes called drifts, are tapered. The taper extends from the end to about one-third the length of the punch. The small end of the punch determines its size. This type of punch is used to start driving straight or taper pins. It can withstand the heavy hammer blows required to break the pin loose and start it moving. The starting punch is also used to knock out rivets after their heads have been cut off. After the pin has been driven partially out of the hole, you can no longer use the starting punch. The increasing taper on the punch becomes too large for the hole. Instead, use the pin punch, which has a straight shank. Always use the largest size of starting punch



43-474

Figure 3-15. Types of punches.

and pin punch that will fit the hole. Never use a pin punch to start a pin; since it has a slim shank, a hard blow can bend or break it.

The prick punch, shown in figure 3-15, is used to make marks in metal for laying out work. The punchmarks are erased by oil or water as pencil lines or marks would be.

Another punch that is very useful is the center punch. Refer to figure 3-15, and note that this punch has a blunter point than the prick punch. The center punch is designed for marking the location of a hole to be drilled. When the drill is placed in the center punchmark, it starts drilling the hole at that point. If you try to drill a hole without first locating it with a center punchmark, the drill usually starts to move around the piece of metal to be drilled. This is called "wandering," and when a drill starts to wander, you can't control the location of the hole. In addition, the cautious repairman uses a center punch to make some corresponding punchmarks on two or more parts in an assembly before he starts taking it apart. This helps him later when he must reassemble the parts in their original positions.

Exercises (240):

1. What type of punch is used to mark metal for drilling?
2. Name the punch to use to finish removing a pin.

3. To start driving a pin, you should use what type of punch?
4. What type of punch can you use to make erasable marks on metal for laying out work?

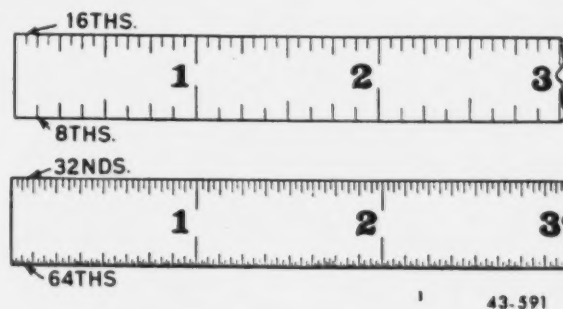
3-2. Measuring Tools

As a pneudraulic specialist, you will need to know how to use and read the various measuring tools or devices that are necessary in your work. You will be required to make measurements that are accurate to ten-thousandths of an inch when bench testing and repairing certain pneudraulic system parts.

You must use, care for, and store the various measuring tools properly in order to insure the retention of their accuracy. Maintenance personnel sometimes fail to realize that inaccurate measurements are seldom the fault of the measuring devices; instead, they are the fault of our in correct use and interpretation of them.

The purpose of this section is to give you the necessary information so that you can properly use these tools of the trade. It is important for you to become acquainted with the various types of measuring tools available and to have a knowledge of their most effective uses.

This text is not intended to be so complete as to contain an adequate description for the use of all laboratory types of calibrating instruments. Rather, it is intended as an elementary text covering the most common measuring tools and gauges used by the pneudraulic system specialist, with suggestions regarding how they may be used to the greatest advantage. The suggestions offered are based on the most popular manner in which measuring devices have been successfully used for many years. In some cases, such as left handedness, alternate methods may permit more efficient use by certain



43-591

Figure 3-16. Two sides of 6-inch rule.

individuals. As you gain experience through your extended use of such devices for measuring and gauging, you will discover additional useful applications and successfully apply them. Until you have gained proficiency through experience, it is recommended that, as nearly as possible, you apply the methods described in this instruction.

241. Indicate the types, proper use, and proper care of simple measuring devices.

Steel Rules. As a pneudraulic systems mechanic, you will find that the common 6-inch flexible steel rule will be suitable for certain measurements that you may be required to make. Other types of rules often used are narrow rules, hook rules, and slide caliper rules. The narrow rule is convenient on work where the ordinary rule is too wide; the hook rule is a valuable rule for measuring inside dimensions where the hook is an advantage; and the caliper rule is used for measuring outside diameters quickly.

Because you may be required to use various rules frequently, it is important that you become thoroughly familiar with the usual graduations, and learn to read them quickly and accurately. Once you understand the 6-inch rule, the use of other types becomes merely a question of applying them to the work at hand. Ordinarily, the two surfaces of a 6-inch rule are graduated on the edges in 8ths and 16ths of an inch on one side, and in 32ds and 64ths of an inch on the other side. (See figure 3-16.) The following method is recommended for learning to read the 6-inch rule. First, learn the 8ths, 16ths, 32ds, and 64ths by becoming thoroughly familiar with the readings shown in figures 3-16. You should soon be able to obtain accurate measurements quickly with any type of rule.

Thickness Gauges. A thickness gauge is used to measure the clearance between two surfaces. As a pneudraulic systems mechanic, you use the thickness gauge when you adjust such items as brakes. The thickness gauge (also called a feeler gauge) resembles a pocketknife with many blades, as shown in figure 3-17. All the blades have the same shape, but each is accurately ground to a definite thickness, which is marked on the blade.

The blades of a thickness gauge usually range in thickness from 0.0015 (fifteen ten-thousandths) inch which is about the thickness of a sheet of paper. By selecting combinations of two or more blades, you can measure any gap or clearance up to the total thickness of all the blades. Notice in figure 3-17 that the thinner blades are placed between the heavier blades. Do you know why this is so? This arrangement is to prevent kinks and creases in the thinner blades. When you use the thinner blades in combination, always try to protect them with the heavier blades of the combination.

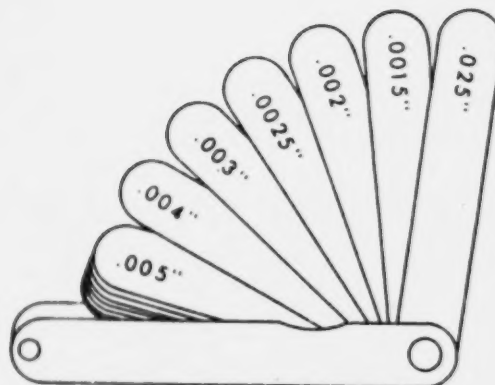


Figure 3-17. Thickness gauge.

Before you use the thickness gauge, always wipe the blades clean with a clean cloth to remove the film of oil, grease, or dirt that may be on them. When you use the thickness gauge to check the gap between two surfaces, always remember that the accuracy of the gauge will depend to a large extent upon your ability to determine by feel when there is the correct tension or pressure on the blade or blades. You can get accustomed to the feel of the thickness gauge by measuring the gaps between two surfaces of a known dimensions.

Spring Scale. A spring scale, such as the one in figure 3-18, is used to check or adjust the specific force required to operate some mechanisms. For example, a spring scale is used to check the amount of force to actuate the landing gear handle. Spring scales are available in various capacities. The ¼- to 25-pound, and the 1- to 50-pound sizes are commonly used. In using a spring scale to adjust tension, be sure that the pull of the spring is perpendicular to the center of the lever being checked; otherwise, you will get an erroneous reading.

Thread Gauge. A thread gauge is very useful when matching nuts and bolts or when ordering replacement parts. Without such a gauge it is often difficult to see the difference in bolts even though they are lying side by side. (See figure 3-19.) This gauge has leaves, or blades, that measure from 8 to 80 threads per inch. When you use this gauge, you must take care to select the proper leaf, especially on the finer threads. The teeth of the gauge leaf seats along the full length of the leaf when the correct one is applied to the threads. If the teeth do not seat all the way, try the adjoining leaves until you find one that does. The number on the leaf indicates the number of threads per inch (pitch).

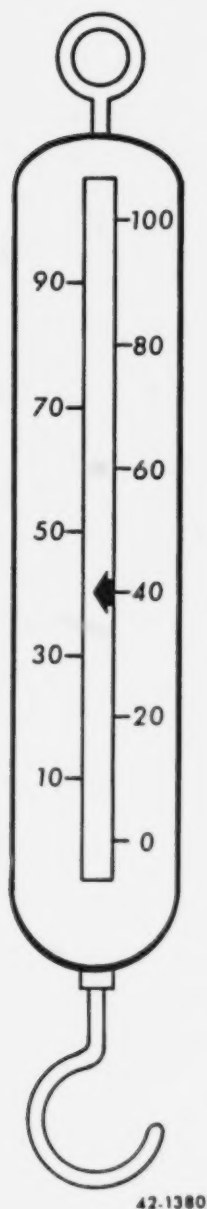


Figure 3-18. Spring scale.

Exercises (241):

1. What is the smallest measurement that can be made with a 6-inch rule?
2. For what purpose should you use a thickness gauge?

3. The thin blades are always placed between the thick blades of a thickness gauge to prevent _____ and _____ in the thinner blades.
4. When using the thickness gauge to check the gap between two surfaces, what important point regarding accuracy should you always keep in mind?
5. Place a "+" in the space beside each task for which a common 6-inch steel rule can be used. Place a "O" beside each task that would be better accomplished by using another measuring tool.
 - a. Measuring the length of bolts.
 - b. Measuring the circumference of a hydraulic cylinder.
 - c. Measuring outside dimensions.
 - d. Determining the clearance between two surfaces.
 - e. Measuring inside dimensions.
 - f. Measuring the length of a crack.

242. State the purpose of a manometer and cite operational features of a mercury and a water manometer.

Manometers. Manometers are used to make accurate measurements. Since each manometer consists of a glass tube, the only restriction or resistance would be between the glass tube and the liquid inside. Two common varieties exist in your shop; mercury and water manometers. Mercury manometers do not show small differences in pressures as well as water manometers. Two types of manometers are shown in figure 3-20. The manometer on the left is a U-type manometer, and the one on the right is a well-type manometer.

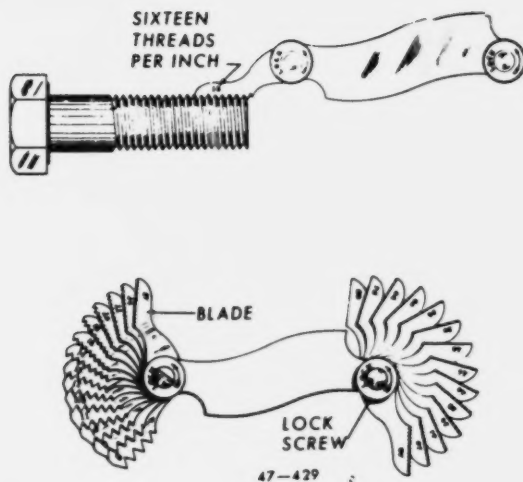
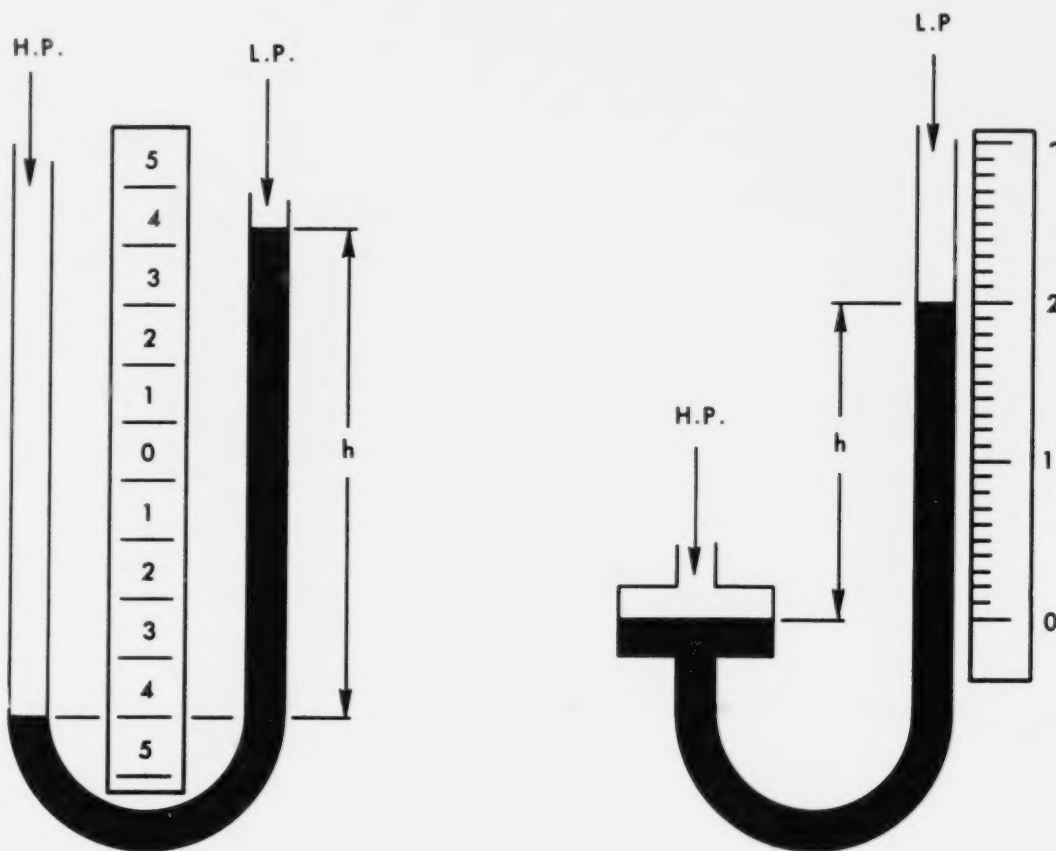


Figure 3-19. Thread gauge.

U-type manometer. Some U-type manometers have a steel measuring tape that can be moved up and down to obtain direct readings. When this type is used, apply the pressure to be measured, and move the zero mark on the tape to the surface of the lower mercury column; then read the number of inches of mercury or water from the surface of the higher column. Other U-type manometers have measuring scales that cannot be moved. The manometer on the left side of figure 3-20 has a fixed measuring scale. When you use this type of instrument, the mercury or water in one side of the U moves as far down from the zero point as the mercury or water in the other side moves up. The total pressure is the distance between the two surfaces of liquid. The lowercase *h* (for height) in the illustration indicates the total pressure. The pressure applied in figure 3-20 has moved the left column of mercury or water down 4 inches, and the right column up 4 inches. Therefore, the pressure reading illustrated is the sum of these two distances, or 8 inches of mercury or water.



58-259

Figure 3-20. Manometers.

Well-type manometer. The well-type manometer has a single straight tube. Along the side of the tube is a scale that is adjusted so that the zero mark on the scale is even with the surface of the mercury or water when no pressure is applied. When pressure is applied, the liquid rises in the tube, and the pressure is read directly from the point on the scale to which the mercury or water rose. This instrument is illustrated on the right side of figure 3-20. The letters H.P. and L.P. refer to the high-pressure and low-pressure sides of the instrument. You apply pressure to the side of the manometer labeled "H.P." The lowercase h indicates the height of the mercury or water column that gives the pressure reading. Read this distance directly from the scale. In the illustration, the pressure source is exerting a pressure of 2 inches of mercury or water.

Converting the manometer readings. You now have only one more problem to solve. The readings you have obtained are in inches of mercury or water, and you must convert these readings to psig (pounds per square inch gauded). One psi (pounds per square inch) is equal to 2.036 inches of mercury. Any reading you obtain in inches of mercury can be converted to psig by dividing the reading by 2.036. For example, if your manometer reading was 4.072 inches of mercury, your psig reading would be 4.072 divided by 2.036, or 2 psig. It may be more convenient for you to convert psig to inches of mercury. In this case, simply multiply the psig figure by 2.036 to obtain the equivalent inches of mercury pressure. In the case of a water manometer, approximately 28 inches of water pressure is equal to 1 psig. To convert water pressure to psig, use the example above, substituting 28 inches for 2.036 inches.

Exercises (242):

1. What is the purpose of a manometer?
2. What is the significant difference between a mercury manometer and a water manometer?
3. How is the sliding tape on a manometer set to read pressure?
4. Which tap on the well-type manometer do you apply pressure to?
5. Convert the following two readings to psig.
 - a. 10.18 inches Hg = _____ psig.

b. 140 inches H₂O = _____ psig.

243. Specify constructional features and operational characteristics of the dial indicator.

Dial Indicator. The dial indicator, if used properly, is one of the most useful devices in your shop. The reading shown on this measuring instrument can help you determine whether the item being checked requires adjustment, repair, or replacement. You may have seen a dial indicator used to check the out of roundness or end play of a shaft. Figure 3-21 shows a dial indicator of the type commonly used. Note that the face of the indicator had large numerals around the outer edge, starting with zero. These numerals indicate thousandths of an inch; i.e., five thousandths, ten thousandths, fifteen thousandths, etc. This indicator has a minus side and a plus side.

When you are setting up the dial indicator, make sure that the contact point is touching the part to be tested. Also, make sure that the dial pointer is

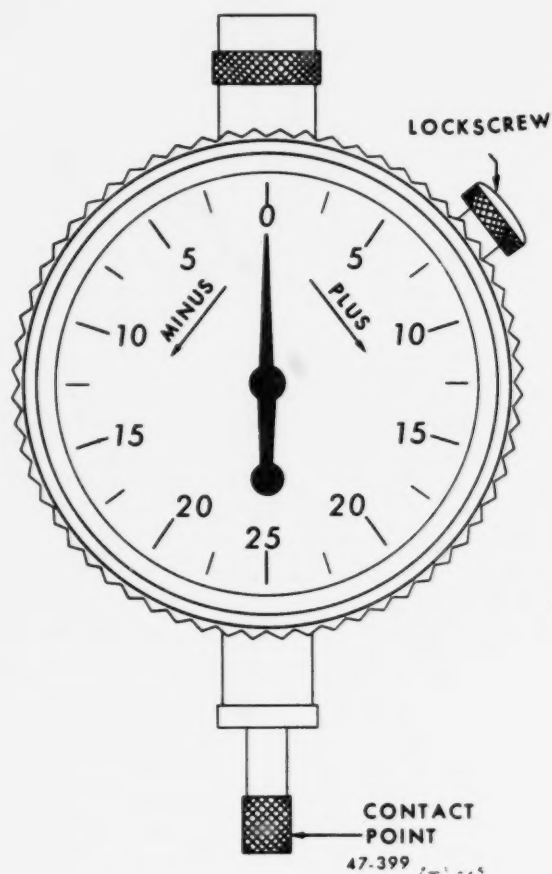


Figure 3-21. Dial indicators.

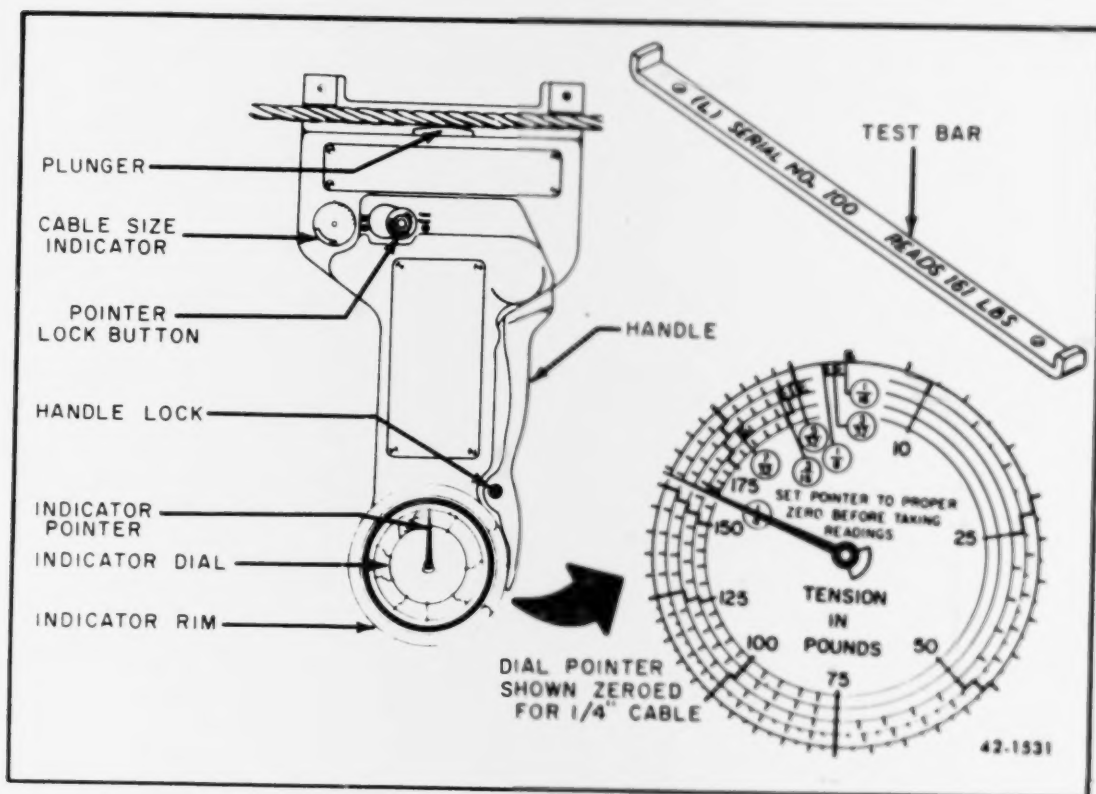


Figure 3-22. Tensiometer.

pointing to zero. To zero it in, loosen the lock screw, shown on the instrument, and rotate the dial. Then tighten the lock screw. Any movement of the part, either toward the dial indicator or away from it, causes the pointer to move. The amount of movement is indicated in thousandths of an inch. When the part moves away from the dial indicator, the pointer will indicate on the minus side of the dial. If it moves toward the indicator it will read plus. By adding the minus reading and the plus reading, you obtain the total movement of the pointer. If the reading are 0.003 inch on the minus side, and 0.005 inch on the plus side, the total movement is $0.003 + 0.005$ or 0.008 inch.

Exercises (243):

1. Cite at least two measurement capabilities of the dial indicator.
2. How would the dial indicator be zeroed in?

3. What way will the pointer in the dial indicator move when the part moves away from it?
4. How do you get the total movement of the pointer?

244. Identify the parts of a tensiometer and specify procedures used to determine cable tension.

Tensiometer. To determine the amount of tension on a cable, a tensiometer is used. When properly maintained, a tensiometer is 98 percent accurate. Cable tension is determined by measuring the amount of force needed to make an offset in the cable between two hardened steel blocks, called anvils. A plunger is pressed against the cable to form the offset. Several manufacturers make a variety of tensiometers for the Air Force, each type is designed for different kinds of cable, cable sizes, and cable tensions. In the information that follows, we discuss the C-8 (USAF type No.). An

understanding of this type should enable you to use the other types of tensiometers that are available.

Figure 3-22 shows a representative type of C-8 tensiometer. Observing the figure, notice that the tensiometer consists of anvils and a plunger to clamp the cable, for which tension is being measured in place. This particular tensiometer is designed to measure tensions from 10 to 200 pounds. Also, observe that a cable size indicator is installed to measure the size of the cable for which tension is being measured. The purpose of the handle on the tensiometer is to clamp the cable in place or to release the cable during tension measurements. Tension readings are taken on the indicator dial that can be preset (zeroed) for the cable size that is being measured. Now read the steps outlined below that show how the tensiometer is operated when you are checking cable tension.

Step 1. Determine cable size being measured.

- a. Lock tensiometer handle to closed position by means of the handle lock.
- b. Rotate cable size indicator counterclockwise to stop position.
- c. Clamp tensiometer on cable by releasing handle slowly (depress handle to release from locked position).
- d. Close and lock handle.
- e. Read cable diameter on cable size indicator.

Step 2. Zero indicator pointer for cable size being measured by rotating the indicator rim so that point is zeroed over cable size being measured (see lower right detail above).

Step 3. Measure cable tension.

- a. Clamp tensiometer on cable by releasing handle slowly.
- b. Read cable tension on individual dial for particular cable size being measured. (observing lower right detail, notice that circled cable size has a line pointing to dial to be read.)

NOTE: If indicator dial is not visible during a measurement, slide point lock button to "ON" before removing tensiometer from cable.

If a tensiometer is suspected of being incorrect, you can check it with the use of the test bar shown in the upper right-hand corner of the illustration. The indicator rim must be zeroed for 1/16-inch cable, and the test bar inserted in the tensiometer with the end marked "L" to the left and with the flanges pointing up. The average of three or more tension values obtained should be within 2 percent of the value indicated on the test bar if the tensiometer is accurate.

Exercises (244):

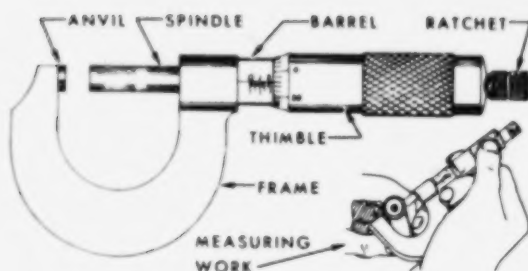
1. What is the purpose of the cable size indicator?

2. Where is the cable placed on the tensiometer?
3. What is the purpose of the handle?
4. How could you look in the cable tension indicator before removing the tensiometer from the cable?
5. In what direction would the cable size indicator be rotated before the tensiometer is clamped on the cable?
6. What happens when the tensiometer handle is released when measuring a cable?
7. How can you check the tensiometer for accuracy?
8. Specify how the tensiometer is zeroed.

245. Specify characteristics of the micrometer and precautions to be observed in its use, and given illustrations, conclude the micrometer readings.

Micrometers. Micrometers, often called mikes, are measuring tools designed to provide precision linear measurements. The measurements are usually expressed or written as a decimal. For example, 2.000 inches written decimally indicates exactly 2 inches. All figures to the left of the decimal point are whole numbers; the figures to the right of the decimal point indicate parts of whole numbers. Starting from the decimal point and moving to the right, the first digit indicates tenths; the second, hundredths; the third, thousandths; and the fourth, ten thousandths. Thus, 2.1 is read two and onetenth; 2.16 is read two and sixteen-hundredths; 2.162 is read two and one hundred sixty two-thousandths; and 2.1624 is read two and one thousand six hundred twenty four-thousandths.

Three types of micrometers are commonly used: (1) the outside micrometer, (2) the inside micrometer, and (3) the depth micrometer. We will talk about the outside micrometer only. The general procedures involved in reading this micrometer can be applied to the inside and depth micrometer.



53-75

Figure 3-23. Micrometer.

Outside micrometer. With the outside micrometer you can measure the outside dimension of an object, the thickness of a metal plate, or the outside diameter (O.D.) of a tube or piece of wire. The frame (figure 3-23) of the micrometer is made in different sizes to accommodate various objects. The size of the object that the micrometer can measure is generally stamped on the side of the frame. Keep in mind, though, that some manufacturers will not stamp the size on the micrometer. In this case, you will have to look at the micrometer and determine what size of object it will measure. This is really not much of a task once you are familiar with micrometers. If your micrometer is marked with "O-1," then it is definitely made to measure objects up to 1 inch in thickness; if it is marked with a "5-6," it is obviously for objects measuring between 5 and 6 inches. Some frames may have a single number instead of a dual number. If the number is 3, it indicates that the largest measurement to be taken with that micrometer is 3 inches. The range of the micrometer, then, is between 2 and 3 inches; the range is the distance between the largest and smallest measurements that can be taken with the tool. Micrometers usually have a 1-inch range.

Now refer to figure 3-23 again, and let's see how an outside micrometer measure. The object to be measured is placed squarely between the anvil and the spindle. The anvil is fixed to the frame and is stationary with respect to it. Anvils are shaped according to the use to which the tool is put; they may be flat, rounded, or tapered on the end. The spindle is fastened internally to the thimble that, when turned, moves the spindle nearer to or farther from the anvil.

One of the greatest abuses of this type of micrometer is overtightening (turning the thimble too hard against the work). The pressure to be used during measurement is that required to bring the anvil and spindle against the surface of the object being measured, a light pressure supplied by thumb and forefinger being adequate. The micrometer should never be tightened enough to support its own weight. On many micrometers a friction

mechanism called a ratchet is incorporated in the end of the thimble. The ratchet is preset to slip if too much pressure is applied to it. Therefore, if your micrometer has a ratchet, turn the thimble with the ratchet, and you will safeguard the tool and its accuracy. Many micrometers have a lock that can be identified by a knurled ring located in the frame around the spindle. When the lock is applied, more pressure is required to turn the thimble. The lock is used to secure the thimble after it has been positioned; thus, this lock enables the tool to be handled without disturbing the reading.

When the thimble is turned, it moves either inward or outward on the barrel on which there are two series of graduations and a line, as shown in figure 3-24. This line, which extends lengthwise along the barrel, is known as the revolution line. Perpendicular to this line are the major graduations. The major graduations are numbered 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 on the tool with a 1-inch range. Each of these major graduations represents 0.1 inch. Each of the smaller graduations on the barrel (there are three between each major graduation represents 0.025 inch. The thimble will move laterally a distance equal to the space between two minor graduations when it is rotated once. Four revolutions will move the thimble (and spindle) exactly 0.1 inch.

Around the inner end of the thimble there are 25 equal calibrations, or divisions. Each division represents 0.001 inch, since one revolution moves the thimble 0.025 inch. Usually every fifth division is marked. Thus, the numbers 0, 5, 10, 20 are found on the tapered end of the thimble, and these numbers are used in computing the dimension of an object. The number located on the tapered end of the thimble and aligned with the revolution line indicates the number of thousandths the thimble has moved past the last smaller graduation on the barrel.

Refer to figure 3-24 again and let's assume that the dimension reading is taken on a 0 to 1 micrometer. The thimble is positioned so that the second major

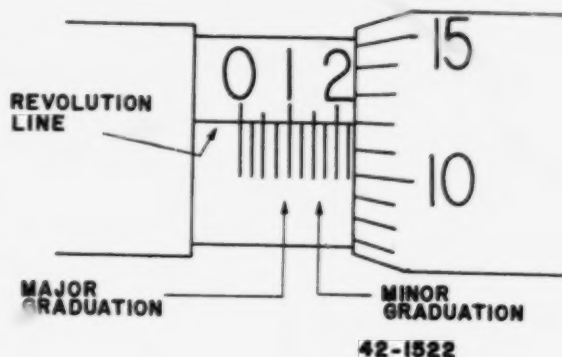


Figure 3-24. Reading a micrometer.

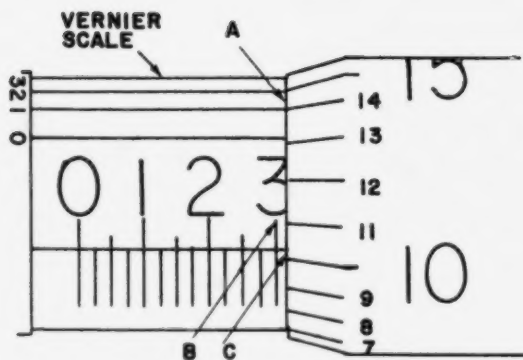


Figure 3-25. Reading a micrometer with vernier scale.

graduation on the barrel is fully uncovered. Observe that the scale indicates a reading of 0.200 inch. One smaller graduation on the barrel is completely uncovered. We will add the equivalent of this graduation, bringing in the measurement up to 0.225 inch. You will notice that the twelfth graduation on the thimble is aligned with the revolution line. Therefore, 0.012 inch is added to give a total measurement of 0.237 inch. The same reading found on a 4-inch micrometer would indicate a dimension of 3.237, because the range of this micrometer is between 3 and 4 inches. Thus, we find that we have one additional step to consider when using an outside micrometer to measure anything greater than an inch. That step consists of adding the minimum possible measurement indicated on the frame to the reading obtained from the micrometer.

In addition to exercising caution when applying pressure to the thimble, you must remember to handle these tools with care. When not in use, they should be kept clean and, if practicable, coated with light oil to prevent corrosion. In the case of 0- to 1-inch micrometer, do not close the gap between the anvil and spindle tightly when storing the tool for this may destroy its future accuracy.

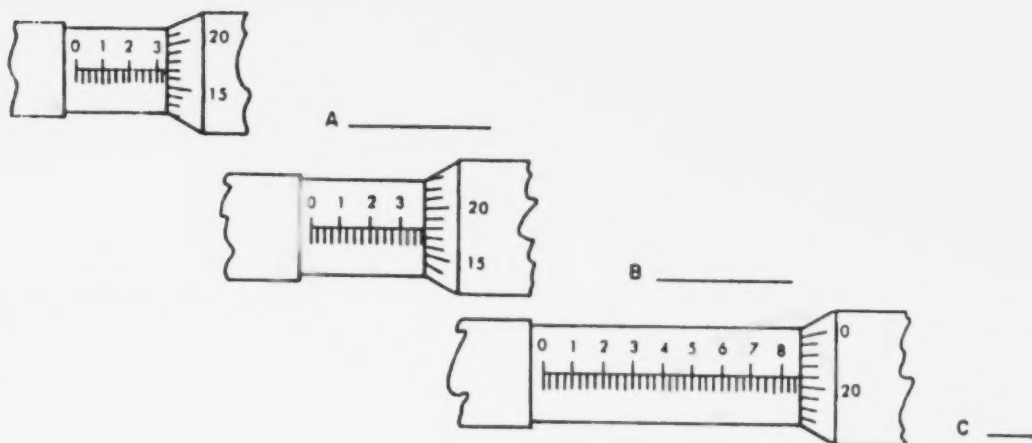
Outside micrometer with vernier scale. Any micrometer that can be read to ten-thousandths of an inch has an additional scale. It is called the vernier scale. With the use of a vernier, it is possible to divide the thimble calibrations into 10 equal parts, resulting in a reading in increments of ten-thousandths of an inch. The vernier scale consist of 10 equally spaced, numbered lines which extend lengthwise along the barrel, parallel to the revolution line, as shown in figure 3-25. These lines occupy the same amount of space as nine lines on the thimble. The effect of this 10-part vernier is to split the thousandths into ten-thousandths. When reading the vernier scale, use the scale number that is most closely aligned with any calibration on the thimble. As an example, consider a reading on a 0 to 1-inch micrometer (figure 3-25). In the

illustration the major graduation "3" (B) is uncovered, indicating that the surfaces being measured are at least 0.300 inch apart. Since no minor graduations after the 3 are uncovered, no units are added from the barrel. Instead, read from the thimble calibration where you find that the tenth graduation is the last one to pass the revolution line (C). Add 0.010 inch for the thimble reading to obtain a total reading of 0.310 inch. Now read the vernier scale where you find that the No. 1 graduation of the vernier (on the barrel) is most closely aligned with a calibration on the thimble (A). This final figure, 0.0001 inch, is added to those already determined to yield a complete measurement of 0.3101 inch.

Whenever you read a micrometer scale of this type, remember to read only those major graduations fully uncovered and progress to the next finer scale to determine the value of the "partially used" graduations. In the above example, a bit of the major scale is uncovered, and it indicates that the dimension was greater than 0.300 inch. The next finer scale indicates that the measurements have increased 10 full thousandths beyond the 0.300-inch mark. Since the movement is slightly beyond the 0.010-inch mark on the thimble, you must look at the vernier to determine the exact amount.

Exercises (245):

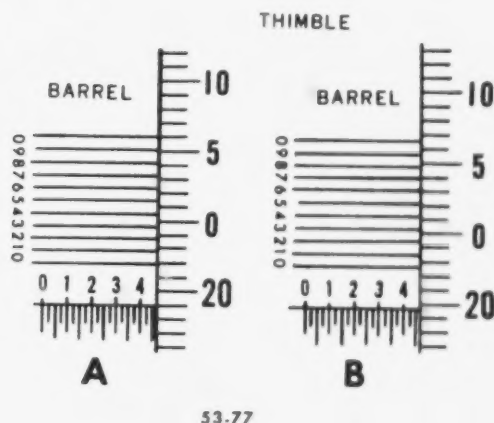
1. Cite the greatest abuse of an outside micrometer.
2. Why must the object to be measured be placed squarely between the anvil and spindle?
3. When storing a micrometer, why shouldn't the spindle be tightened against the anvil?
4. How would you determine the micrometer reading using a vernier scale?
5. In determining the micrometer reading, how many revolutions would you have to turn the thimble of a micrometer to read 0.025 inch?
6. Record the correct readings for a 1- to 2-inch micrometer illustrated in figure 3-26.



43-596

Figure 3-26. Objective 245, exercise 6.

7. Record the correct reading for a 1- to 2-inch micrometer illustrated in figure 3-27.



53-77

Figure 3-27. Objective 245, exercise 7.

246. Specify the types, proper use, and proper care of torque wrenches.

Torque Wrench. Torque wrenches are used to measure torque (twisting force) applied to bolts and nuts when they are being installed. Some wrenches are designed to measure torque in inch-pounds; others, in foot-pounds. The most common type torque wrench used in the Air Force is the "breakaway," sometimes referred to as the

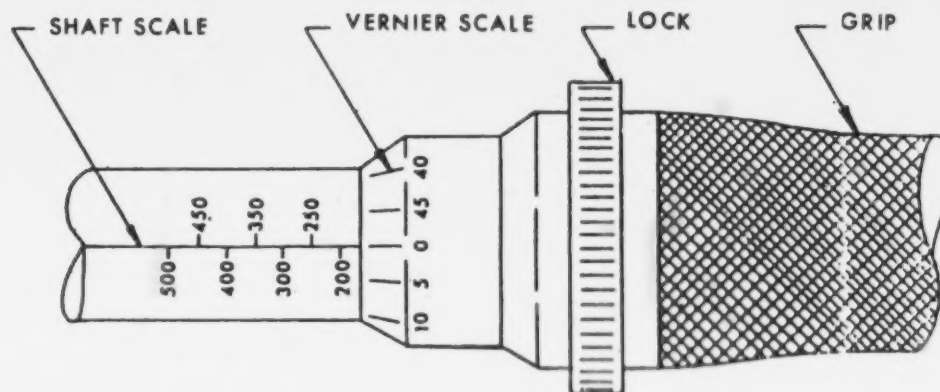
automatic release-torque wrench. The breakaway torque wrench has a square drive, shaft scale, vernier scale, grip or handle, and grip lock.

Breakaway torque wrenches are adjustable, and a desired torque can be set (within limits of the torque wrench) by turning the handle or grip to settings on the micrometer-type scale. The micrometer-type scale consists of the shaft scale and vernier scale. Referring to figure 3-28, notice that the shaft scale is graduated in 50 inch-pounds. The vernier scale is graduated from 0 to 50 inch-pounds.

To increase the torque setting of the wrench, turn the handle or grip clockwise. To reduce the torque setting, turn the handle or grip counterclockwise. Turning the handle lengthens or shortens the handle; it also changes the scale reading of the micrometer-type scale while reducing or increasing tension on the spring inside the handle. The desired torque setting should always be approached from the lower end of the micrometer-type scale.

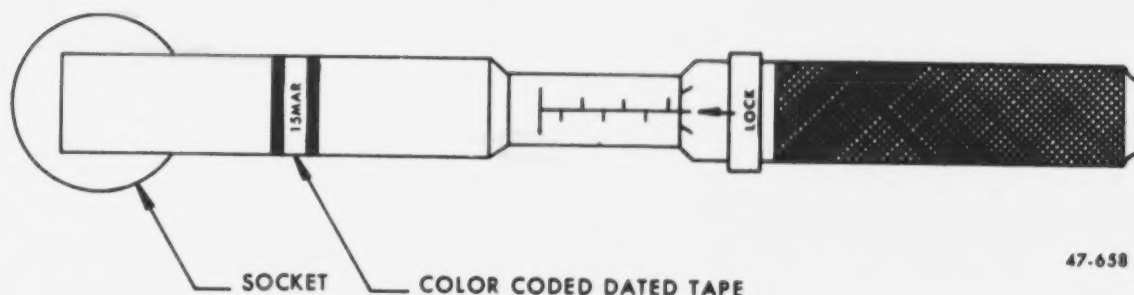
The breakaway torque wrench has a locking device to insure that the desired torque value does not change when the wrench is being used. Some wrenches are turned to engage the locking of the handle. In other wrenches, locking is done by sliding the lock along the handle to engage a pawl or slot in the shaft. In either case, the grip is prevented from turning when the wrench is in use. The lock must be "unlocked" before the handle (grip) can be turned. The lock can be "locked" only when a number on the vernier scale (0, 5, 10, etc.) is in line with the shaft index line.

You can use this wrench almost as you would any other. But be sure to pull the wrench in a clockwise direction with a smooth and steady



47-656

Figure 3-28. Torque wrench reading.



47-658

Figure 3-29. Torque wrench verification tape.

motion. A fast or "jerky" motion will result in an improperly torqued nut or bolt. When the torque applied reaches the predetermined torque setting in the handle, the wrench automatically releases (breaks away). You then have approximately 15° to 20° of free travel. The release is distinct and easily detected, and indicates that you have reached the correct torque. This is your signal to release the force being applied to the wrench.

Torque wrenches issued from supply to shops or toolcribs for use in the maintenance of aircraft and other critical equipment, should be checked and calibrated at least once every 2 months (60 days). The 60-calendar-day period is to be calculated from the date of the verification. (NOTE: Verification is a checking operation to determine accuracy or inaccuracy on a torque wrench tester. Calibration is the actual adjustment necessary to bring the torque wrench into acceptable tolerance.) Thus, a torque wrench verified on 15 March 1975 would be due for reverification on 15 May 1975. At the time of verification, a color coded, dated tape is fastened to the torque wrench, as shown in figure 3-29. The

following colors of tapes are used to indicate the month that the torque wrench is due for verification:

Colors	Months
Blue	January-May-September
Red	February-June-October
Black	March-July-November
Yellow	April-August-December

(NOTE: If the tape is lost or the wrench is dropped or otherwise abused, its accuracy must be verified, and if necessary, it must be calibrated prior to further use.)

To obtain accurate reading from the torque wrench, you must observe certain rules. One is to care for the wrench as you would any precision tool. Another rule is to make sure the threads of the nuts, bolts, etc., that will be torqued are in good condition. You should also lubricate the threads before applying the torque, unless otherwise specified.

When using a torque wrench to tighten a series of nuts, never tighten one nut to the specified

torque before starting to tighten the other nuts. Instead, tighten each nut a little until they all meet the specified torque. Nuts opposite (or diagonal to) each other should be tightened in sequence.

After using these wrenches, you should turn the grip counterclockwise to its lowest setting and lock it. If the torque wrench is one that reads 700 to 1600 inch-pounds, it should be turned to exactly 700 (lowest setting). If the torque wrench is one that reads 0 to 150 inch = pounds, it should be set on 0.

This action removes the tension on the spring in the handle. The accuracy of the spring tension determines the accuracy of the wrench. With the torque wrench at its lowest setting, it should be stored in its own storage container.

The following are a few precautions to observe concerning torque wrenches.

a. An extension must not be used on the grip end of the handle.

b. A torque wrench must not be used to break loose previously tightened bolts.

c. A torque wrench must not be used to apply a greater amount of torque than the rated capacity of the wrench.

d. Do not attempt to change the setting when the handle is in a locked position.

e. Do not place an extension on the square drive to increase the length of the torque wrench unless you have mathematically calculated the torque value to set on the handle.

Exercises (246):

1. What is the most common type of torque wrench used in the Air Force?
2. How do you reduce the torque setting on a torque wrench?
3. Torque wrenches must be verified at least once every _____.
4. Whenever you finish using a torque wrench, you should adjust it to its _____ setting.
5. How is the torque value of a torque wrench expressed?

6. How can you determine when a torque wrench was properly calibrated?

7. If a torque wrench is dropped, what action must be taken?

247. Given specific information on torquing a fitting, calculate the torque value required.

Torquing with an Extension. When a torquing application is such that an extension is required, as shown in figure 3-30, the correct setting for the torque handle may be determined by the following mathematical formula:

S = Handle setting

T = Torque applied at the end of adapter

La = Length of handle in inches

Ea = Length of extension in inches

NOTE: The length of the extension as used herein is the distance between the center of the square drive and the center of the wrench opening. The length of the handle must always be the distance between the center of the square drive and the center of the hand grip. For example, if it is desired to exert 100 inch-pounds at the end of the extension, when La equals 12 inches and Ea equals 6 inches, it is possible to determine the handle setting by making the following calculation:

$$S = \frac{T \times La}{(La + Ea)}$$

Substituting the known values, in the above example, we have

$$S = \frac{100 \times 12}{(12 + 6)}$$

Now we multiply 100×12 , which will give us 1200. Then add 12 and 6 together to give us 18. Divide 18 into 1200, which comes out 66.6 inch-pounds. This is the amount you will have to adjust the torque wrench to come up with 100 inch-pounds at the end of the extension.

When it is necessary to attach an extension at an angle, as shown in figure 3-30, the effective length of the assembly will be La + Eb. In this instance, length Eb must be substituted for length Ea in the formula.

Occasionally, when using the torque wrench, you may need to convert inch-pounds to foot-pounds, or vice versa. For converting inch-pounds to foot-pounds, divide the figure to be converted by 12. For example, 600 inch-pounds divided by 12 equals 50 foot-pounds. ($600 \div 12 = 50$)

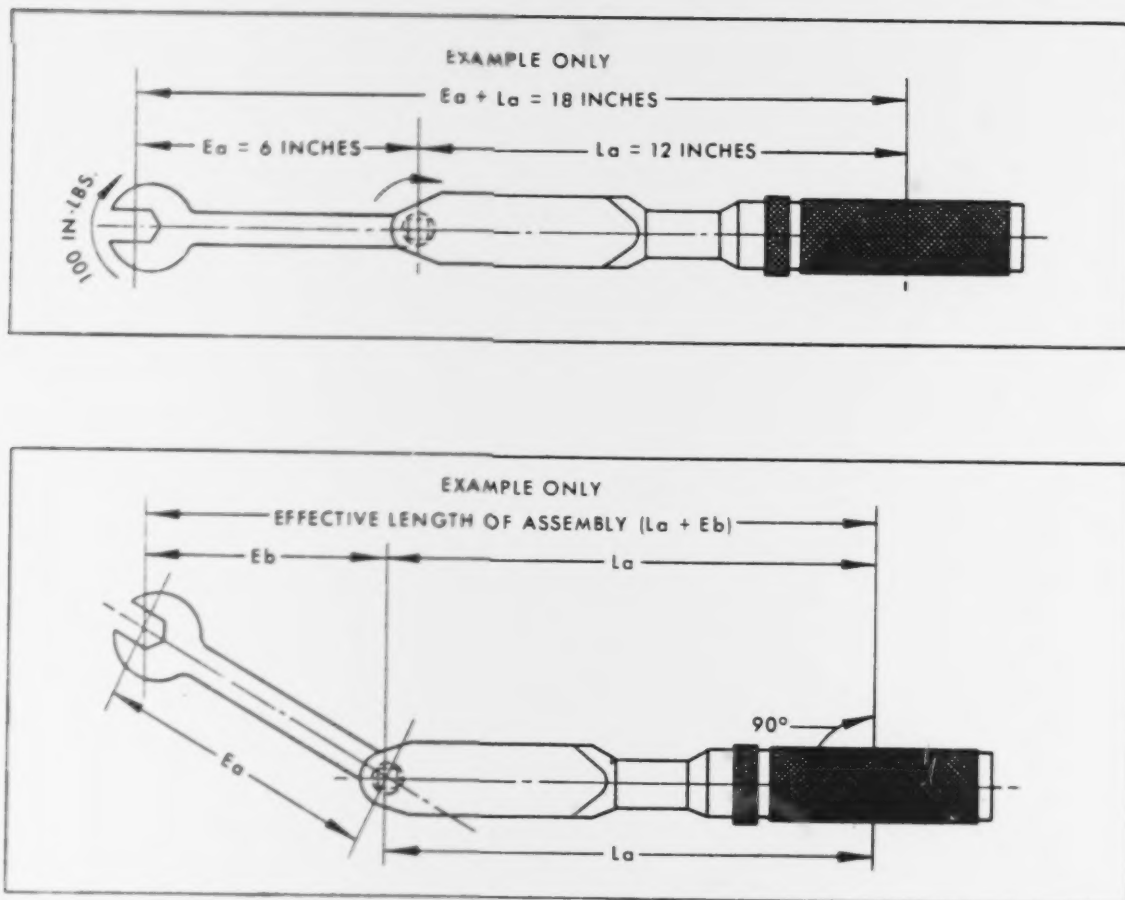


Figure 3-30. Torque wrench application.

Exercises (247):

Use the following information in answering the questions below. You want to torque a fitting to 100 inch-pounds, and you are using a torque wrench that measures 12 inches from the handle grip to the square drive.

1. If you used an extension in line with the handle that is 3 inches long, what is the required torque going to be?
2. If an extension is placed on the torque wrench at an angle, with the centerline of the handle with E_b of 8 inches, what is the required torque?

3. A torque wrench which measures in foot-pounds is going to be used to torque a fitting to 300 inch-pounds. How many foot-pounds will you have to adjust the torque wrench to get the inch-pounds torque?

3-3. Special Tools

The handtools we have discussed so far have been tools commonly used by all maintenance personnel. We next discuss tools that are designed to perform specific jobs. In most cases, the tools used for pneudraulic maintenance are not highly complicated, but they are designed for a specific purpose. In your hands, as a skilled and informed specialist, tools help produce a finished product of which you can be proud, because the product will properly do "its thing."

Experience will teach you the need for special tools, holding jigs, and fixtures. Look around your shop and you will see many items classified neither

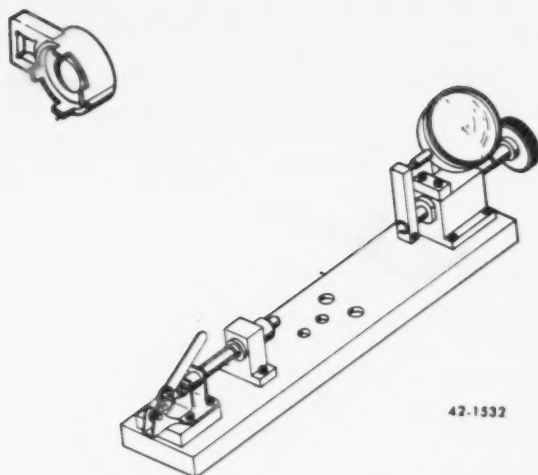


Figure 3-31. Special tools.

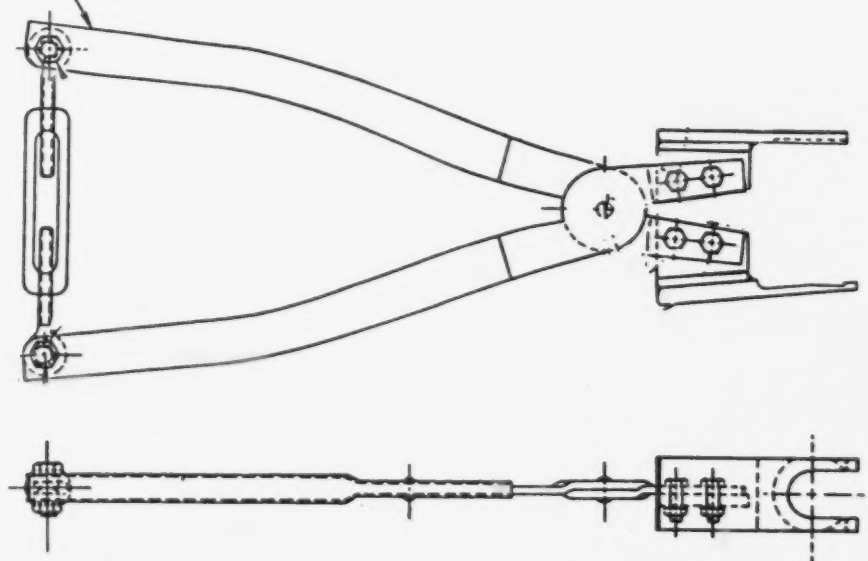
as common handtools nor as measuring devices. Some are large and others are small, but all are used to make a hard job easier. These devices, can be obtained through normal supply channels, or in many cases they can be locally manufactured. It is beyond the scope of this CDC to discuss all the

special tools needed, because of the multitude of aircraft, and the special tools each requires to perform maintenance. We have selected some tools that can be ordered through supply, and others that can be locally manufactured.

248. Indicate whether given statements correctly reflect facts pertaining to identification of special tools needed, use and care of special tools and jigs, and manufacture of special tools and jigs.

Listing of Special Tools. If you remember our discussion of overhaul instructions of off-equipment technical orders, you will remember one of the first sections of the overhaul instructions lists the special tools necessary for overhaul. Figure 3-31 shows two special tools required during the overhaul of a servo valve. One is a special wrench used to remove a gland nut, and the other is a special holding fixture to hold the servo valve during repair testing. If your shop is authorized to overhaul the servo valve, then you will more than likely be able to order this wrench for your shop. The technical order lists the special tools by part number, so all you will have to do is convert the part number to a stock number, show justification and the wrench is practically yours.

MODIFIED INTERNAL
RING PLIERS



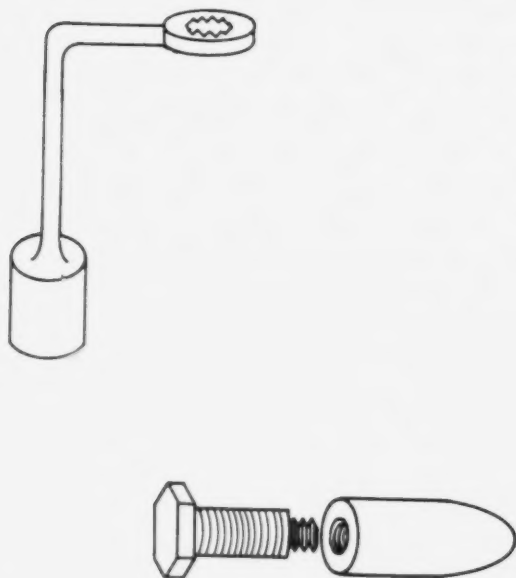
42-1533

Figure 3-32. Special tool specifications extracted from TO.

Manufacturing and Designing Special Tools and Fixtures. In figure 3-32 you see a drawing of a special tool that was extracted from an aircraft technical order. In other words the technical order gave specific instructions on how to manufacture a tool instead of ordering it. If the special tools or fixtures can not be manufactured right there in your own shop, submit the drawing through channels to the shop best suited for the job. The special tool shown is a modified pair of internal snap ring pliers which is used to compress the spring on the leading edge flap actuator of an F-4 aircraft.

It may be necessary, however, to design other special tools or to redesign existing fixtures to fit new situations. Figure 3-33 shows some special tools that were designed to perform specific jobs. One of the items, a bullet, can be used to aid you while installing seals. It can be manufactured in different sizes, and is usually made out of brass or aluminum. It will help install shaft seals on pumps, and install bolts or fittings through seals. The thing to remember about this type of special tool is that it must be kept smooth at all times. If it is dropped or abused in some other way, it could very easily cut the seal rather than help you install it.

Another special tool shown in figure 3-33 is a box-end wrench, that was cut off, bent at a 90° angle, then welded to a socket. This will allow you to connect a torque wrench to it so you can torque a fitting or bolt. When manufacturing special tools,



42-1534

Figure 3-33. Locally manufactured special tools.

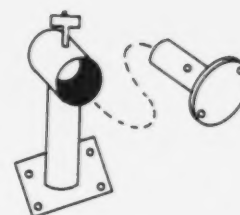
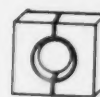
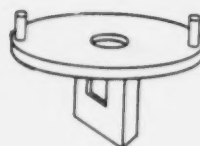


Figure 3-34. Holding fixtures.

especially when they have to be heated, you have to be careful that the temper (hardness) is not taken from it.

Figure 3-34 shows some locally manufactured holding fixtures and jigs. The top one is a holding fixture that can be placed in a vise, then have a pump mounted on it. This will allow you to torque the fittings, or repair the pump. The middle picture shows a jig that can be used to hold several holding fixtures for brakes. The holding fixture can be removed and another one inserted. This jig is extremely useful when working on several aircraft, each of which requires different brakes. Of course this jig should not be limited to just brakes alone; use your imagination for its use. To mount such a jig, you should have a strong workbench or table with a thick, unpainted, hardwood top. You wouldn't want to mount such an item on a flimsy table that will fall apart the first time you put something heavy on it.

If you design or improve on an existing special tool or fixture, remember the suggestion program. If your equipment is particularly helpful in doing a certain job, other shops in the Air Force could benefit from it as well.

Exercises (248):

Mark each statement with a T if it is true or F if it is false.

- 1. Information on special tools, jigs, and fixtures can be found in the overhaul technical order for that part.
- 2. Special instructions on how to manufacture the tool can be given in a technical order.
- 3. The bullet shown in figure 3-33 can be ordered through supply channels.
- 4. The box-end wrench, shown in figure 3-33, can be used with a torque wrench to torque a fitting or bolt.
- 5. A fixture is used to hold a component during repair.
- 6. The bullet is usually made of iron or steel.
- 7. A strong workbench should be available for the mounting of a jib.

249. Specify procedures used to verify calibration of precision measuring equipment.

Precision Measurement Equipment (PME). Practically every type of aircraft pneudraulic system has special equipment for checking the condition, adjustment, or calibration of specific units in the system. This special equipment is called precision measurement equipment or test equipment. Test

equipment can come in many forms. It may be as simple a device as a "gauge" used to check the pressure in the hydraulic system, or as complex as a hydraulic test stand. This test equipment will be a valuable maintenance aid because it enables you, the pneudraulic systems mechanic, to insure the seviceability and the reliability of the units it is designed to test.

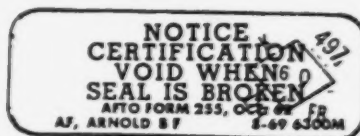
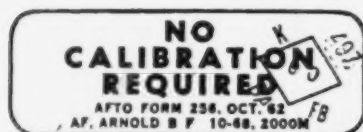
Before using any test equipment, check it to insure that it is all there, and that it is in serviceable condition. There is probably nothing more discouraging than lugging a piece of test equipment from the shop to the flight line, then finding that all pieces that you need to perform your test aren't with it. After using the equipment, store it properly. Return all parts to their proper storage container so that the next time the equipment is needed it will be there.

Test equipment requires verification (checking for accuracy) and calibration (adjusting for accuracy) at scheduled intervals. If the unit must be checked, the check will be performed by the precision measurement equipment laborator (PMEL). When the check (or calibration) is completed, an AFTO Form 108, PME Certification Label (figure 3-35), will be affixed in a conspicuous place upon the item.

IDENTIFICATION NO. Q4500/SH0063	
FUNCTION 33K8-4-1-1 (5)	
DATE CALIBRATED	DATE CALIBRATED
ALL	ALL
DATE CALIBRATED	DATE CALIBRATED
14 JAN 74	14 JUN 74
DATE CALIBRATED	DATE CALIBRATED

USER CERTIFICATION LABEL			
IDENT. NO. SH0029CALIB. INTERVAL 6 mo			
AUTH. 3307-4-29 CALIB. FOR ALL			
CERTIFIED BY	DATE DUE	CERTIFIED BY	DATE DUE
XQS	14 JUL 74		
14 JAN 74			

AFTO FORM 27 MAR 71 PREVIOUS EDITION WILL BE USED



42-1520

Figure 3-35. Calibration labels.

If the calibration is done by work centers other than PMEL, then an AFTO Form 27, User Certification Label (figure 3-35), is attached. AFTO Form 394 (figure 3-35), Certification Label, is used when the equipment is too small to accommodate either an AFTO Form 27 or 108. The labels will tell you when the next calibration is due. Always check the label for the calibration due date before using the equipment.

If it shows that the check is due or past due, do not use the equipment until it has been checked by PMEL for accuracy. These calibration requirements are covered in the 33 category (test equipment) TOs. These test equipment TOs list each item that requires calibration and the calibration time requirements for each.

On complex PME, such as test stands, one certification label will suffice for all items that are an integral part of it. An item is considered an integral part if it must be calibrated as a part of the stand. Equipment normally removed from the stand for calibration is not an integral part, and will accordingly have individual certification labels.

One other form you will come in contact with is the AFTO Form 255, Notice Certification Void

When Seal Is Broken (see figure 3-35). It is placed on the equipment in such a manner that any attempt to repair or adjust the equipment will result in breaking the seal. If the seal is broken, you have no idea whether the equipment is calibrated correctly. The equipment must then be rechecked or calibrated if necessary.

Some units of test equipment do not require scheduled checks. Figure 3-35 shows an AFTO form 256 used on this equipment. This does not imply that they may be handled carelessly or abused. You have a responsibility to properly care for all equipment issued by the Air Force, whether it is assigned to you, or your shop.

One rule that should be followed is, whenever an item of equipment leaves your shop, you should have a signed receipt for it. AF Form 1297, Temporary Issue Receipt (figure 3-36), is used to issue an item of equipment for short periods of time. Let's say an engine mechanic needs to borrow a special wrench to remove a pump from an aircraft. Have him sign for it on a temporary receipt, which then holds him responsible for the equipment until it is returned.

DONALD U. DUCKWORTH AIC 3345CMS		A35HX		19 JAN 77	
TYPED OR PRINTED NAME, GRADE AND ORGANIZATION		TO: (Responsible Officer)		ORG. ACCT. NO.	
DATE (ITEM(S) TO BE RETURNED)					
STOCK NO.	DESCRIPTION	UNIT	QUANTITY ISSUED	COST	
5120-00-821-3441	TORQUE WRENCH	ea.	1	\$12.50	
I ACKNOWLEDGE RECEIPT AND RESPONSIBILITY FOR ITEM(S) SHOWN IN "QUANTITY ISSUED" COLUMN, WHICH WILL BE RETURNED ON DATE SPECIFIED ABOVE.					
DATE	SIGNATURE	DUTY PHONE	ISSUED BY		
18 JAN 77	Donald U. Duckworth	2560	T36T Bob L. Chavez		

AF FORM 1297

PREVIOUS EDITIONS WILL BE USED

TEMPORARY ISSUE RECEIPT

GPO: 1972-487-688

Figure 3-36. AF Form 1297, Temporary Issue Receipt.

Exercises (249):

1. Who is to perform the check on the precision measuring instrument?
2. Describe what you should do before you use test equipment.
3. What is the difference between verification and calibration?
4. Where would you find information concerning calibration requirements for test equipment?
5. Which form would you use to loan a special tool to another mechanic on a temporary basis?
6. What is the purpose of AFTO Form 255?
7. What form will be placed on a piece of precision measuring equipment if calibration is done by a work center other than PMEL?

Test Instruments and Nonpowered Aerospace Ground Equipment

THE PNEUDRAULIC systems mechanic performs maintenance that requires the use of electrical test meters, a leak tester, and nonpowered aerospace ground equipment. His duties will include such maintenance activities as troubleshooting systems, repairing hydraulic components, and servicing the pneudraulic systems.

All test equipment is used to measure some quantity of an operating device or systems. This can be pressure, volume, speed, size, etc. In this chapter we cover two pieces of test equipment you will find useful; the multimeter, which will measure the electrical quantities of voltage, current and resistance; and the ultrasonic leak detector, which will locate an internal or external leak by the sound it makes.

Jacks and maintenance stands are also used by the pneudraulic systems mechanic. Jacks are used mainly to raise the aircraft wheels off the ground for working on the landing gear and wheels, and for making retraction tests. Maintenance stands have hydraulic elevating gears to raise them. They are used for working on aircraft sections that cannot be reached from the ground. In this chapter we will cover maintenance stands, their construction, operation and use. In some cases you will be required to maintain this equipment. Even if you are not required to maintain it, you are liable for any damage incurred to its misuse or abuse.

Other nonpowered aerospace ground equipment you will often use are hydraulic and nitrogen servicing carts. In this section we shall cover the use and operation of an air/nitrogen servicing cart and hydraulic fluid servicing cart.

4-1. Testing Instruments

Without electrical troubles there would be a marked reduction in the work that the pneudraulic mechanic has to do. However, identifying and locating electrical troubles can be an exciting and thought-provoking part of your work. Most troubles that are apt to occur in any electrical circuit will stem from two basic causes; an open circuit and a short circuit. The meter you will use to detect these troubles will be the multimeter.

The pneudraulic systems mechanic must also locate leaks in a hydraulic system. If these leaks are in an open area they are quite easily seen. If however, these leaks are in an area that is not accessible they become difficult to find. The tester that we will cover to help you locate the inaccessible leaks is the ultrasonic leak detector.

250. Specify precautions for use of the multimeter, and from given situations specify control knob setting and/or meter readings of a multimeter.

Multimeter Control Knob Settings and Meter Scales. An AN/PSM-6 series VOM, one of which is shown in figure 4-1, is a typical general-purpose, precision test instrument. It is used for measuring volts, amperes, and ohms. The test readings are indicated on one of the three scales. They are the AC voltage scale (bottom), the DC voltage and milliamperes scale (middle), and the ohms scale (top). The RANGE selector switch is used for selecting the desired scale range; the FUNCTION switch for selecting the proper circuit for measuring volts, ohms, or milliamperes; and an OHMS ADJ knob for zeroing the pointer on the ohms scale. This pointer must be zeroed to compensate for a decrease in battery voltage due to age and use. The two test jacks are the plug-ins for the red (positive) and black (negative) test leads.

Setting Up a Multimeter for Voltage Checks. Referring to figure 4-1, you will notice that the FUNCTION switch has two D.C.V. (direct current volts) positions. In either position, the pointer refers to the same scale as set by the RANGE switch. The difference between the two positions is the number of ohms per volt; that is, one position (1k Ω /V) connects to a 1000-ohm-per-volt meter circuit; the other position (20k Ω /V) connects to a 20,000-ohm-per-volt meter circuit. The 1000-ohm-per-volt meter circuit protects the meter against overloads, but reduces its sensitivity or accuracy.

Electrically controlled hydraulic components may be powered by either AC or DC voltage. Always check to see what type of voltage is used to operate

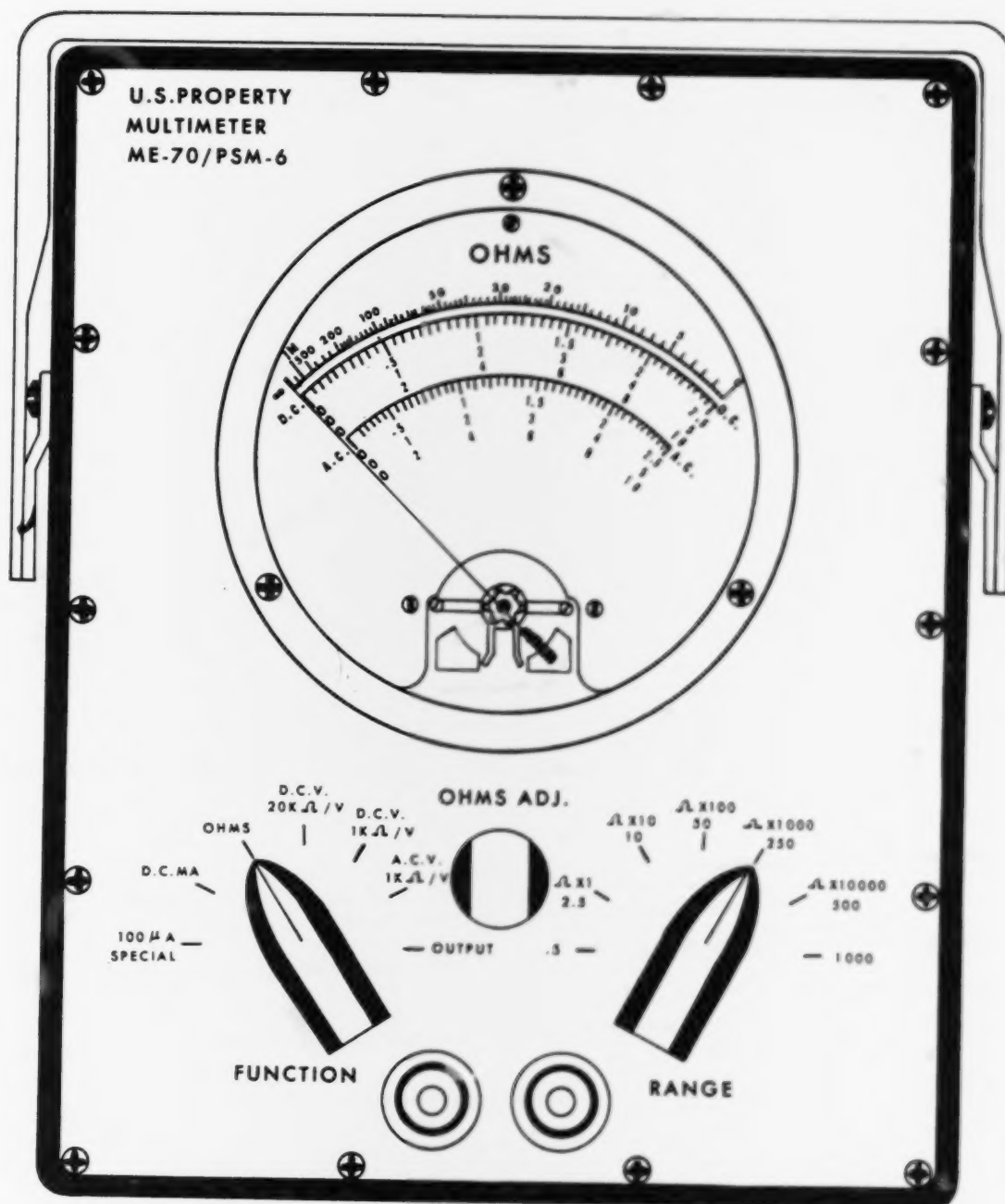


Figure 4-1. Typical multimeter.

the component. Let's assume that the components being checked operate on 28-volt DC. In this case, set the FUNCTION switch to the D.C.V. 20k Ω /V position. Next, set the RANGE switch to the 50-volt selection. Be sure that your setting is higher than the operating voltage of the component or circuit being tested. Next, install the test leads into the input jacks. The black lead should be placed in the black input jack and used as a ground. The red lead should be placed in the red input jack and used as the power lead. A voltmeter is always connected to the circuit in parallel or across the conductor or unit being checked.

After properly connecting the test leads, you are ready to take the voltage readings. The voltage reading is taken on the 0-5 division (center) of the DC scale. This scale is used for the .5-, 50-, and 500-volt selections. For example, put the RANGE selector on the 50-volt setting. If the pointer points to the 3 on the 0-5 scale, the voltage indication is 30 volts. Likewise, on the 500-volt setting, if the pointer points to the 3, the voltage indication is 300 volts.

From previous discussions, you learned that a certain amount of voltage is expended in forcing current through a resistance. Any time there is a difference in voltage between two points, current flows. A voltmeter measures that difference in electrical pressure. If there is no difference between the voltmeter lead touchpoints, it will read zero.

Figure 4-2 shows a circuit containing several voltmeters with various voltage indications. To properly troubleshoot an electrical system, you must understand why the various voltage indications shown in figure 4-2 were obtained.

Notice that the voltmeter D indicates 24 volts, which is the voltage of the battery. Meters E and G indicate 24 volts, which is the amount of voltage drop across each of the light bulbs. Meter H indicates 18 volts, the voltage drop across the

motor. This leaves 6 volts indicated on meter B. Meters C and F indicate zero volts, because there is no voltage drop between the test leads. If there were a broken wire between the switch and the fixed resistor, H and B would read zero. All other meters would read the same as shown.

Notice that meter A indicates zero. This is true because there is no voltage drop across the switch. If this switch were opened, meter A would indicate a voltage drop of approximately 24 volts. With meter A removed, meters B and H would indicate zero voltage. These same indications would result for an opened circuit breaker. An open in an electrical wire will give approximately source voltage when a meter is placed across an open. You may be wondering why there is a 24-volt indication across an open. You may wonder especially when a motor and resistor are in series with an open. When there is an open in a circuit, there is no current flow. The entire circuit on one side of the open will have the same voltage as the battery terminal to which it is connected. The entire circuit on the other side of the open will have the voltage of the other battery terminal. There is a 24-volt difference between battery terminals, so there is a 24-volt difference across the open also.

Setting Up a VOM for Ohmmeter Checks. Refer again to figure 4-1. When the FUNCTION switch is set on OHMS, the meter pointer is referenced to the top scale. Resistance values are expressed in ohms. The resistance scale may seem confusing at first because it reads just backward from the other scales. However, a little time spent studying the scale will clarify this matter. When there are many ohms of resistance, only a little current will pass. This causes only a small movement of the pointer. When setting up the multimeter for ohmmeter checks, you first set the FUNCTION switch to OHMS. Set the RANGE switch to the value you estimate is enough to cover the resistance in the

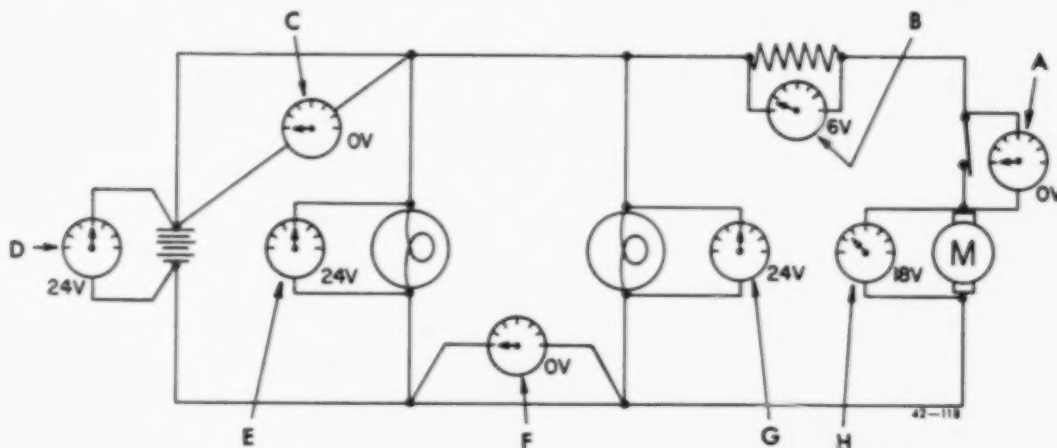


Figure 4-2. Voltage indications, series-parallel circuit.

circuit. You may also want to consider the degree of reading accuracy required in selecting the range. (This information can be obtained from the applicable technical order.) Next, insert the test leads into the input jacks. Touch the test leads together so you can zero the meter. Gradually rotate the OHMS ADJ knob until the pointer lines up with the zero mark on the resistance scale. After zeroing the meter, you are ready to make your ohmmeter checks.

When checking resistance with an ohmmeter, be sure the component is disconnected from the electrical system. Connection of the ohmmeter to a hot system could damage the meter.

Using an ohmmeter to check components for internal opens or shorts. When using an ohmmeter, place one test lead, see figure 4-3, at the component terminal where the voltage supply wire could connect. Place the other test lead to the component's ground terminal. The meter now should give some sort of reading, depending on the amount of internal resistance of the component. A reading of infinity at this point indicates an open caused by a broken wire, excessive corrosion, or an extremely loose connection. Conversely, a complete short shows up as a zero reading. If the resistor that the ohmmeter is connected to is rated at 12 ohms, then the meter should indicate 12 ohms resistance.

Using an ohmmeter to check components for short between the internal circuit and the component case. Apply one lead to the case of the component, and the other lead to each of the terminals except the ground. In this condition, a reading of infinity indicates that the internal circuit is not grounded out internally. However, a reading of anything other than infinity shows that the internal circuit is grounded out against the case. This may be due to not enough clearance between metal parts and the case, or to broken insulation.

Setting Up the VOM for Ammeter Check. Current measurements are made by placing the function switch to DC ma and the range switch to the desired position. When measuring current of an unknown value, always place the range switch in the highest possible position (1000). When a current indication is obtained, gradually reduce the range of the meter. Remember, the most accurate reading

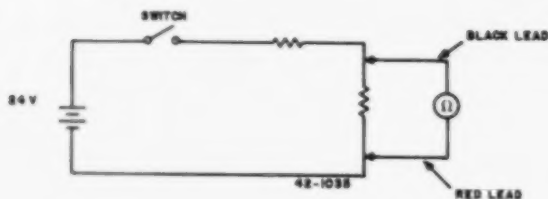


Figure 4-3. Checking for ohms.

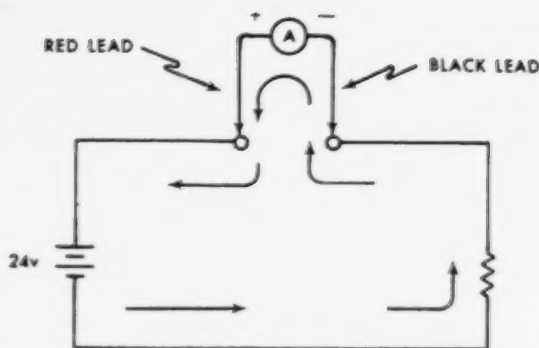


Figure 4-4. Ammeter connected in a circuit.

is obtained at center scale of the lowest possible range. The reading is then taken on the DC scale.

Figure 4-4 illustrates the manner in which an ammeter is connected in a circuit. In order to measure current accurately, the meter must be connected in series in the circuit. The conducting path must be broken and the meter is used to replace the missing part of the circuit. All current in the circuit must pass through the meter.

Exercises (250):

1. With the FUNCTION selector at ohms and the RANGE selector at X1000, what would the resistance be if the meter needle indicated 20?
2. What will the meter read if the FUNCTION selector was at DC ma, the RANGE selector was at 250 and the meter needle was at the 1.5 indication?
3. What is the OHM ADJ knob used for?
4. How is a DC voltmeter connected to a circuit being tested?
5. If the FUNCTION selector is set at D.C.V. 20kΩV, the RANGE selector is set at 50, and the pointer points to the 4, what is the voltage indication?



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Figure 4-5. Ultrasonic leak detector.

6. When checking resistance with the multimeter, what could happen if the electrical power was not disconnected?
7. What will the multimeter read if the FUNCTION selector was at A.C.V., the RANGE selector was at 250, and the meter needle was pointing to 2?
8. When measuring a DC voltage, how are the multimeter leads placed into a live circuit to measure voltage?
9. How would you set the multimeter to measure the voltage in a 24-volt DC circuit?
10. How would you set up the multimeter to measure 3000 Ω of resistance?

251. Specify the use and operational characteristics of an ultrasonic leak detector in locating pneumatic and hydraulic fluid leaks.

Ultrasonic Leak Detector. For many years the most common procedure for detecting leaks in pneumatic systems has been the use of the soap leak test. However, this method is slow, tedious, and expensive, both in man-hours and equipment.

The application of soapsuds requires the operator have a basic knowledge of possible leak locations. Experience has shown that soap testing is generally limited to fittings, valves, and other obvious areas. In practice, however, leaks are often found in unexpected places, such as a pinhole in a long tube. In some instances, it is impossible to closely observe the formation of soap bubbles over a leak.

Because of these known obstacles and the undesirable extra expense, the Air Force has procured the ultrasonic translator leak detector. If this detector is used correctly, it can save you time and equipment. (We commonly drop the word "translator" in the nomenclature).

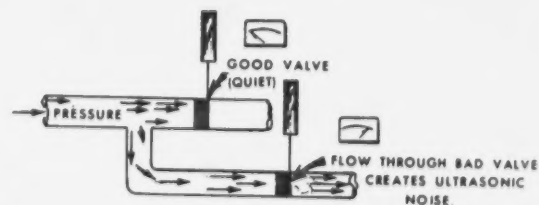
Notice in figure 4-5 that the detector has four fasteners that secure the lid on the detector. The lid, not shown, has a compartment for storing the sensing probe and earphones. The detector has the following components and controls: (1) the sensing probe that senses the sound of an air leak, and converts this sound into an electrical signal; (2) two amplifiers that amplify the sensing probe signal and

convert this signal into visual and audio signals; (3) a speaker that projects the audio signal (located on the upper half of the tester); (4) an ON-OFF switch that applies internal battery power to the tester circuit; (5) a volume control knob used for controlling circuitry sensitivity; (6) an indicator that visually gives the pressure of a leak by its pointer's clockwise deflection; and (7) two electrical jacks, one for connecting a tape recorder, and the other for connecting earphones.

Unless you are using the tester in a noisy area, you will probably not use the earphones. To operate the unit, connect the sensing probe and turn on the ON-OFF switch. Observe the indicator for slight pointer deflection. After the indicator pointer stabilizes, use the volume control and zero the indicator's pointer. Pointer zeroing eliminates indication of surrounding noises. Now the tester is ready for use.

To use the tester, move the sensing probe slowly over the suspected leak area. The sensing probe should be held in a perpendicular position about 6 inches from the item being tested. As the sensing probe approaches the leak area, it picks up the sound of the leak, and the speaker starts giving out the highly amplified sounds. At the same time, the indicator pointer starts deflecting to indicate the presence of a leak. Both the speaker sound and indicator pointer movement are greatest when the sensing probe is immediately over the leak. As the sensing probe is moved away from the leak, both the speaker and indicator pointer have less output. If earphones are plugged in, the speaker is inoperative. The recorder jack may be used to connect a tape recorder to record the leak sounds for later use.

The ultrasonic detector can save many maintenance man-hours when used to its full capability. For example, in locating a leak in pneumatic system, the probe can be run along the outside of the aircraft skin to pinpoint the general area of the leak without removing numerous panels. This detector can also be used to locate units that are bypassing fluid flow internally. (See figure 4-6). By placing the probe against a suspected valve, you can determine (by sound level and needle



42-1820

Figure 4-6. Detecting internal leakage.

deflection) the rushing of fluid if the valve is bypassing.

Exercises (251):

1. When will the earphones be used with the leak detector?
2. Why do you need to zero the indicator's pointer when first using the ultrasonic leak detector?
3. What does the sensing probe do?
4. When is the speaker sound and indicator pointers movement the greatest?
5. If a pneumatic leak is suspected in the aft section of an aircraft that has several access panels, what can you do to pinpoint this malfunction?

4-2. Aircraft Jacks and Maintenance Stands

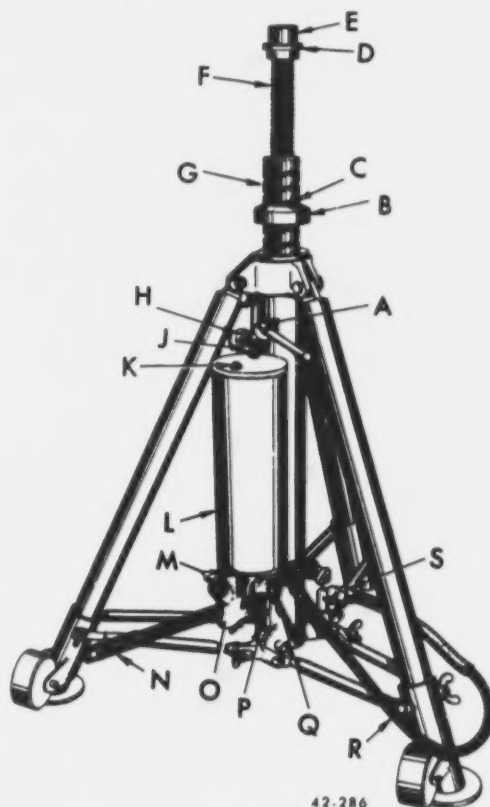
In this section we will talk about aircraft jacks and maintenance stands. Aircraft jacks are generally classified as either wing or axle jacks. Some have a fixed height; others are adjustable. The maintenance stands come in various shapes and sizes. Some of the maintenance stands have weight lifting ability than others. So, for discussion Hydraulic jacks and hydraulically operated maintenance stands must be repaired if they malfunction. The pneudraulic shop, on some bases, has been given this responsibility.

252. Name the two types of jacks and specify the operational procedures and maintenance of them.

Wing Jacks. There are several different types of wing jacks to fit various need. The type most frequently used is the tripod jack. All jacks of this type are basically the same in operation and structure. Some are larger and possess more weight lifting ability than others. So, for discussion purposes, we have chosen the 6-ton-capacity-type B-1A jack (see figure 4-7). It is representative of almost all tripod jacks.

The B-1A is used as a wing jack for fighter and trainer-type aircraft. It can also be used as a nose and tail jack when its height and capacity are

suitable. It is a portable, self-contained, hydraulically operated unit. The jack consists of a basic hydraulic lifting unit mounted in the center of three tubular steel legs. It is operated by a pumping unit connected to the lifting unit by metal and rubber hose (R). The hose is equipped with a quick-disconnect fitting (S) to reduce fluid loss



- 42-286
- A. Reservoir locking cam
 - B. Locknut
 - C. Setscrew
 - D. Extension locknut
 - E. Jack pad
 - F. Extension screw
 - G. Ram
 - H. Jack pad adapter
 - J. Air vent
 - K. Filler plug
 - L. Reservoir
 - M. Pump handle socket
 - N. Pump handle
 - O. Pump handle fulcrum assembly
 - P. Removable hinge pins
 - Q. Needle valve
 - R. Flexible metal and rubber hose
 - S. Quick-disconnect fittings

Figure 4-7. B-1A wing jack, 6-ton.

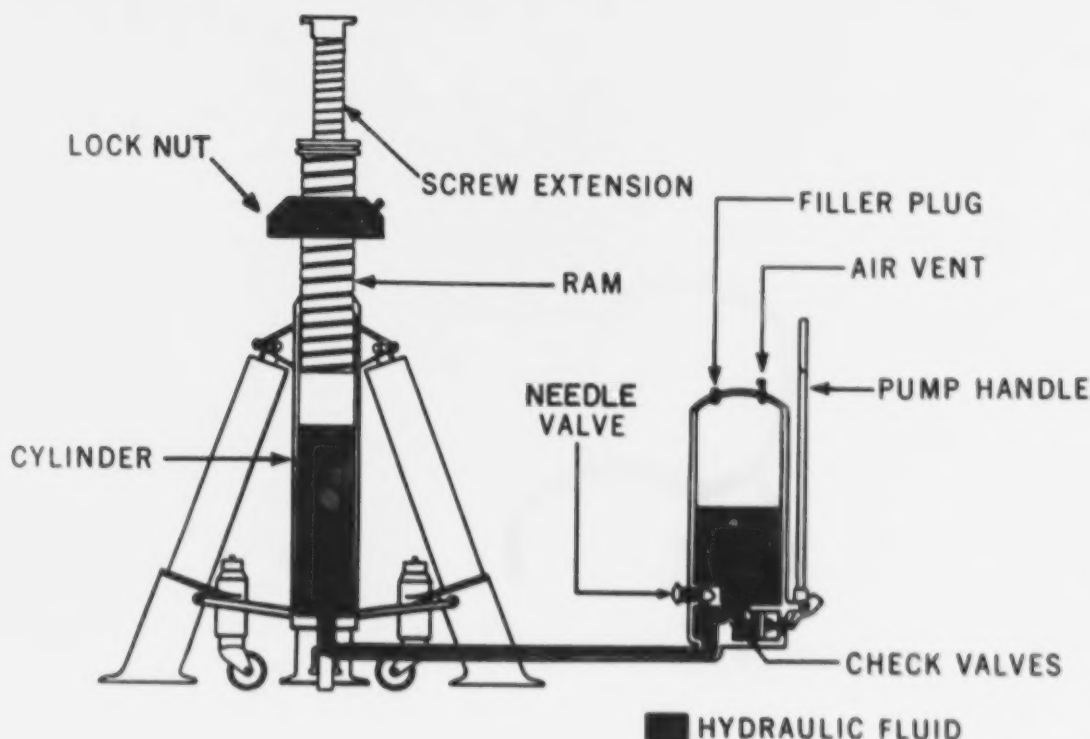
during maintenance. Extensions for the tripod base and the extension screw (F) can vary the height of the jack. Be sure to consult the TO on their use.

The pumping unit consists of reservoir (L) and a simple single-action hand pump. Under normal conditions, the pumping unit is attached to the lifting unit, by locking cam (A). It can, however, be detached from the cylinder and operated on the ground. The speed of operation is determined by the two positions of the fulcrum (O). The fulcrum can be repositioned by the hinge pins (P). The top position gives the greatest travel per stroke to the lifting ram. This position is used for quick raising when positioning the jack. It can also be used for loads up to half of the jack capacity. The lower position, which provides the greatest lifting power, is used when the jack is under full load.

Filler plug K and air vent J are located on the top of the reservoir. Remove the filler plug and check the fluid level before each jacking operation. The air vent is used to prevent a vacuum from being created in the oil reservoir when oil is withdrawn. The air vent is opened by loosening a knurled knob before jacking or lowering. It should be open at any time the jack is under load. Internal pressures can be built up as a result of the thermal expansion of the fluid and air. The needle valve, at the bottom of the reservoir, is part of the pump

casting. This needle valve, when open, allows the fluid to return to the reservoir from the cylinder. This releases the pressure in the lifting unit and allows the ram to settle. If the needle valve is closed, pumping the hand pump will extend the fitting ram.

The primary part of the cylinder assembly is the lifting ram (G). Cut into the outer surface of the ram are steeply pitched threads. Locknut B can rotate up or down the threads. When the ram is being raised, the weight of the locknut will cause it to rotate down the grooves and remain on top of the cylinder. If the ram accidentally lowers, the locknut will bind between the grooves and the cylinder top and will not rotate. The locknut then is merely a safety device to prevent accidental lowering. The nut should always be screwed down against the cylinder except when lowering the load. In this event, the locknut should be rotated up the ram by hand to keep a clearance between it and the cylinder. This allows the ram to lower, but is ready to lock should a pressure failure occur. A setscrew (C) permits locking the locknut to the ram. This should be used when the jack is left standing under a load. The ram is guided in its travel by an upper bearing in the top of the cylinder assembly, and a lower bearing on its lower end. It is prevented from turning by means of the ram key located in the



42-1026

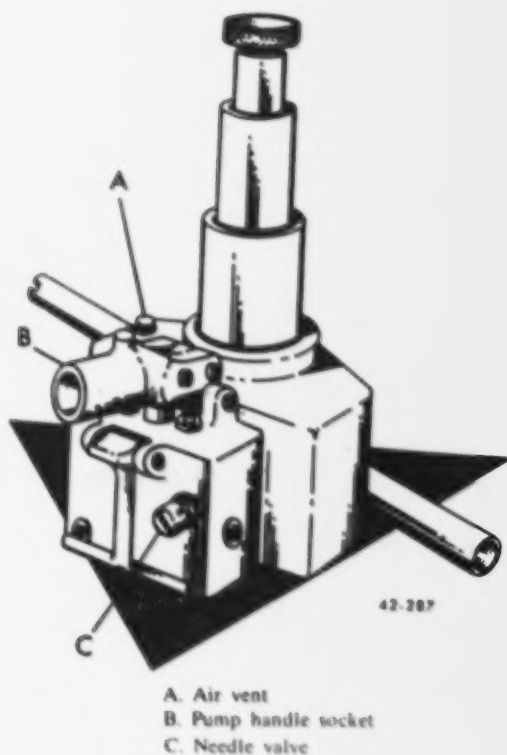
Figure 4-8. Wing jack operation.

upper bearing. The key fits in a vertical slot on the ram (not shown).

The screw extension is also equipped with a locknut (D). It should be screwed down to the top of the ram as soon as the screw has been screwed out the desired distance. It too, is safety device. The jack pad (E) fits the jack pads on many aircraft. If it doesn't, a jack pad adapter (H) placed in the jack pad will meet the need.

Refer to figure 4-8 as we talk about the raising and lowering of the jack. To raise the jack ram, close the needle valve and stroke the pump. Fluid is drawn into the pump as the pump piston moves away from the suction port. It then produces fluid pressure when the pump piston is forced in. Fluid is then sent through a metal and rubber hose to the jack's ram. Fluid will act on the area of the ram's piston, forcing it to rise. Keep pumping until the desired height has been reached. Once this has been accomplished, the ram lock should then be locked.

To lower the jack, the ram must be raised just enough so you can unlock the ram lock. Once this has been done, open the needle valve slowly to lower the jack. The air vent should already be open to prevent a buildup of pressure in the reservoir as the jack lowers.



A. Air vent
B. Pump handle socket
C. Needle valve

Figure 4-9. Axle jack.

Axle Jacks. Axle jacks are often used instead of tripod jacks when brake work or tire repair is being performed. There are several types of axle jacks. Figure 4-9 shows a 5-ton jack which is typical of most hydraulically operated axle jacks. The type to use depends on how high or how heavy the load is, and how much clearance between the load and the ground. Of course you wouldn't use a jack that has a closed height of 6 inches to raise the axle of a B-52 gear. When it is fully extended, it probably wouldn't even reach the axle. The best thing to do is to select a jack that is just a little lower than the axle when the jack is closed. Then there should be no problem.

Like the tripod jacks, in the center ram the axle jack has a screw extension that can be extended for greater height. Notice also that there are three rams instead of one. Because of this, a small, compact jack can be made to extend a great distance. Once again, the pump is built into the reservoir. However, in this jack the reservoir is the base of the ram section. In figure 4-9 you can see that the handle behind the jack fits into the pump handle socket (B). The handle is equipped with notches in the pump end that fit the knobs on the needle valve head. This makes opening and closing of the needle valve (C) easier. There is also an air vent (A) which should be open during extension, lowering, and when under load. At all other times this air vent should be closed.

Inspection and Maintenance of Jacks. We'll use the wing jack previously described as we discuss the inspection and maintenance of jacks. Proper inspection and maintenance of hydraulic jacks help prevent mechanical or hydraulic failure of jacks. In turn, this prevents possible injury to maintenance personnel. You, the hydraulic repairman, may have the responsibility of performing these inspections and maintenance tasks. The technical order pertaining to the particular jack tells you how to do the inspections and maintenance. However, there are some general procedures that pertain to all jacks. For example, before you use the jack, check the base or tripod for looseness and the hand pump for proper operation. Along with this check, look for any hydraulic leaks that may have developed.

Inspect the outer surface of the ram for evidence of burrs, or any deformations that could scratch and mar the upper bearing. If this were to happen, the ram would not lower properly. Also check the steeply pitched grooves of the ram to insure that they are smooth and free of dirt. If the grooves become clogged with dirt or become damaged in any way, the ram locknut could not rotate freely. The locknut should rotate around the ram with such ease that it will move downward by its own weight.

At least once a week the reservoir fluid level should be checked. To service the reservoir, lower the jack completely and remove the air vent and



Figure 4-10. Result of improper use of aircraft jacks.

plug. Place a funnel in the opening and service with hydraulic fluid. The fluid level should be just below the filler opening. Remove funnel and replace the plug; if the jack is not going to be used, close the air vent.

Drain the reservoir and flush it with kerosene (or an approved solvent) at least once every 3 months. Occasionally, lubricate the pump handle pivots and dolly wheels with a light lubricating oil.

When jacks are not in use, they should be stored upright and in a dry place. The ram should be completely retracted down into the cylinder. This prevents dirt and grit from accumulating on the outer surfaces and grooves of the ram.

Sometimes air may get under the ram. If this happens, the jack will not work right. Because the ram is heavy, the air under it must be compressed before the ram moves. After the ram reaches the load, the air must be subjected to more pressure in order to lift the load. Each time pressure is applied against the air, pump strokes are lost. The simplest remedy for this situation is to pump up the ram a short distance. Then lay the jack on its side with the hose connection up. Disconnect the hose at the cylinder and hold open the cylinder side of the quick-disconnect valve. Now press in on the ram. This will expel the air from the cylinder assembly. Bleed the air from the hose by holding the hose side of the quick disconnect open, then operate the pump slowly. When all air is expelled, reconnect the hose.

Exercises (252):

1. Name the two basic types of aircraft jacks.
2. The pumping unit consists of two components. What are they?

3. What is the purpose of the safety locknut on the wing jack?
4. List three reasons why the air vent on top of the reservoir should be opened during operation.
5. To lower the jack, what needs to be done?
6. What determines the type of jack to use?
7. Explain why the ram locknut should rotate freely around the ram by its own weight.

253. Specify general procedures used while jacking an aircraft with wing jacks.

Use of Jacks. When it becomes necessary to jack any aircraft, first consider the element of safety. Before you attempt this operation, consult the maintenance TO for the particular aircraft. There is always a chance that the aircraft may slip and fall

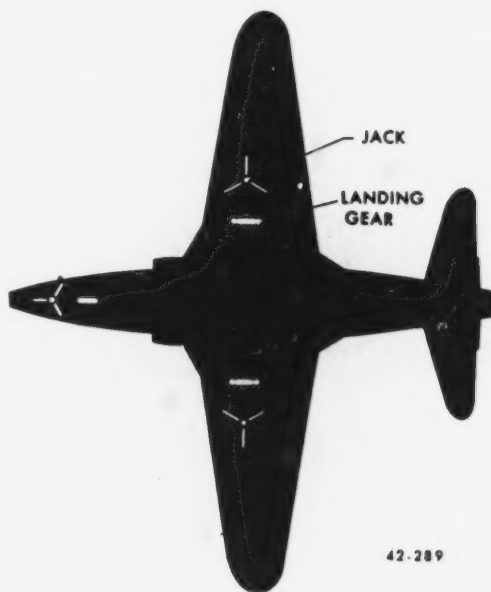


Figure 4-11. Jack placement under aircraft.

from the jacks with disastrous results. Flatheads such as the individual shown in figure 4-10 are now 6 feet under because of their carelessness.

Placing the jack under the aircraft is an important operation that should not be done haphazardly. Figure 4-11 shows how the jacks should be positioned. Know the capacity called for in the aircraft TO and the capacity of the jacks on hand. If you have the proper jacks, again check the TO on how to place them under the aircraft. You will need to know how to place the jack under the wing to obtain greatest support with least danger of slipping.

Figure 4-11 shows wing jacks arranged so that the two inside legs run parallel to the fuselage. The nose jack is placed so that its inside legs run perpendicular to the fuselage. This increases stability. The positioning of the legs is the major item to consider, but another item is the positioning of the wheels. Locate the legs with wheels in a certain manner; make it easy to get the jack from beneath the aircraft quickly as soon as the load is removed from it. Why hurry? You will probably be lowering the aircraft onto its landing gears. Shock struts will often bind a little and not compress to their normal position at once when lowered. They may drop suddenly or possibly hang up until you shake the wingtip a bit. If this should happen, you can see that it would be very easy for the wing to become impaled on the jack. Therefore, the best procedure is to align the legs properly. Have the wheels pointed in the direction you intend to move the jack when it is free. This may not be the way you would do it when working on a smooth floor. It may be just as easy to slide the jack out as it would be to tilt it over and roll it. If this is the case, don't worry about the wheels. However, a crack in the floor or any other rough spot may make rolling necessary.

After the jacks have been properly placed, remove the wheel chocks. Then run the screw extension up to the jack pad. Jack pads are adapter units that allow the jack to fit the jack point on the aircraft. They lessen the likelihood of the jack's slipping and damaging the aircraft. Figure 4-12 shows types of jack pads which fit into the socket of the jack extension screws. Other jack pads are attached to the under side of the aircraft. They are points shaped to fit into the pads on the jacks. The reason for having a variety of jack adapters is to permit the use of one jack for a number of aircraft. All aircraft do not necessarily have the same type of jack pad. The aircraft may have its jack pads permanently attached, or it may require that they be attached for jacking. Some of the aircraft pads may be bolted on; others may snap into place. Still others screw on. When not in use, some aircraft jack pads are stored in the aircraft; others must be stored in the supply rooms of the home base. The TO for the particular aircraft gives instructions on the storage of jack pads.

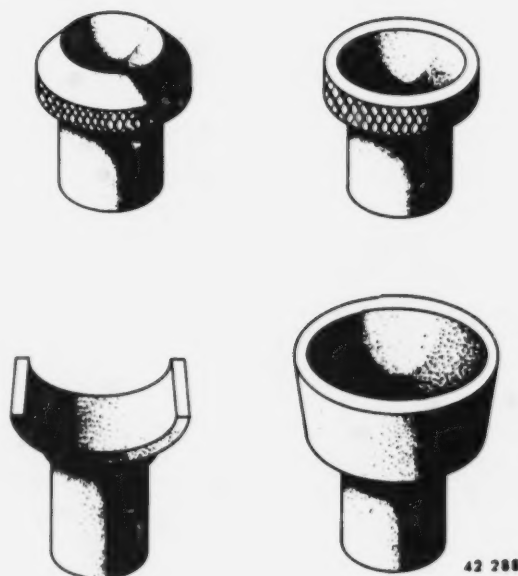


Figure 4-12. Jack pads.

Never tilt the jack to line it up with the aircraft jack pad; instead slide it over. Now open the reservoir air vent, close the needle valve, and start pumping.

When jacking aircraft, be sure to raise all jacks simultaneously. The best way to do this is to have one man on each jack and one "point man" who stands out in front of the aircraft giving directions.

The raising and lowering of large aircraft sometimes require the use of more than one jack under each wing. In fact, as many as three jacks under each wing may be required when raising our heaviest bombers. In this case, a hydraulic jacking manifold (MA-1 card) would likely be used. The hydraulic jacking manifold is a portable unit with pressure lines going to each jack. It provides equal hydraulic pressure to all of the jacks. The manifold pressure for right- or left-wing jacks is controlled by shutoff valves on the MA-1 cart. This allows the aircraft to be jacked evenly.

One word of caution regarding the use of any jack. Always read the applicable TOs before beginning any jacking operation.

Exercises (253):

1. In general jacking procedures, two inside legs of the main gear jacks should be _____ to the fuselage and the legs of the nose gear jack should be _____ to the fuselage.

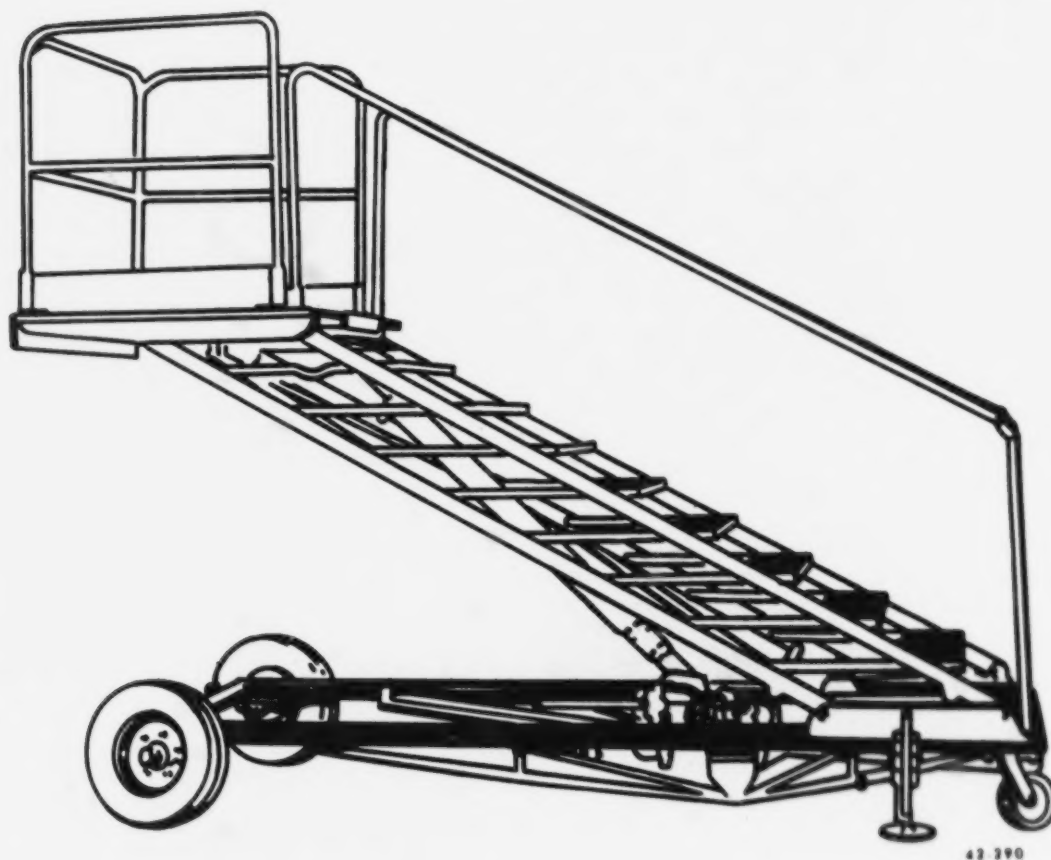
2. Why should the wheels on the legs of the jack point in the direction you intend to move the jack after lowering the aircraft?
3. What is the purpose of having various types of jack pads?
4. What unit is used when raising large aircraft that require more than one jack under each wing?
5. What is the recommended number of personnel required to jack an aircraft?

254. List the various maintenance stands and specify their constructional features and uses.

Maintenance Stands. These stands are designed to provide working platforms at variable heights. A basic stand consists of a base assembly, upper structure assembly, platform assembly, and the larger stands, a hydraulic system for raising and lowering the platform.

As an aircraft pneudraulic specialist you should be familiar with maintenance stands in order to select the proper one for each job. There are several types of stands (platforms) in common use. We shall discuss the most common stands that you will most likely encounter.

Type B-1 maintenance stand. This stand is a hydraulically operated combination of stair structure and work platform, mechanically linked together to enable each to remain level throughout the height range of the stand. (See figure 4-13.) The platform height is easily adjusted by means of a hydraulic hand pump, to any height between its adjustment limits of from 3 to 10 feet. Stair support members and stair handrails are rigged in a manner



43 390

Figure 4-13. B-1 maintenance stand.

to make them self-aligning at all platform levels. The handrail feature of both the stairs and the work platform permits personnel to work at various extended heights in relative safety.

The base of the stand made of welded tubular steel is 11 feet long and 4 feet wide. A cylindrical hydraulic fluid reservoir is welded across the width of the frame. The platform lifting mechanism is a hydraulic cylinder assembly. It is actuated by a hydraulic hand pump also mounted on the base. The hydraulic cylinder assembly connects the base to the upper structure to give lift. It also gives support to the upper structure to give lift. It also gives support to the stairs and platform in all raised positions of the platform.

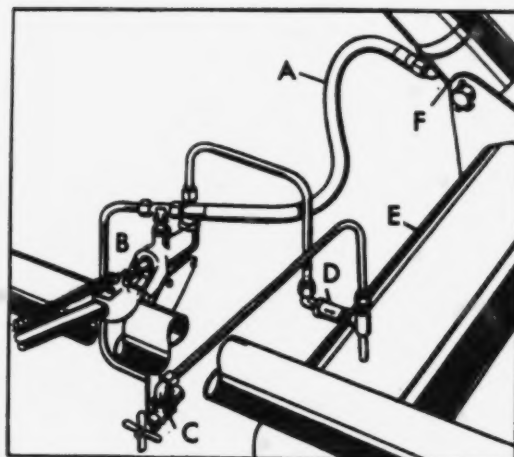
The B-1 maintenance stand has a tow bar bolted to the front of the base frame and a wheel mounted at each corner of the base. The two rear wheels are equipped with 16-inch pneumatic tires and do not swivel. The front wheels are casters with ball bearings on the wheel axles and the pivot shafts. This stand was designed to be towed by a vehicle with the front wheels off the ground. The caster front wheels make maneuvering possible.

Two base locks are bolted to the forward end of the frame to prevent movement of the stand during use. They give stability to the stand when the platform is extended. The locks are spring-loaded, vertical steel stems equipped with foot plates. When the foot pedal is pressed downward, the plates sit on the floor. In the down position the locks tend to relieve the weight resting on the casters and prevent their movement.

The hydraulic cylinder holds the platform at the desired height. To prevent accidental lowering of the cylinder, a safety lock is used. The lock is a U-shaped steel device designed to fit into grooves cut into the cylinder assembly with a length of chain that prevents its being lost or otherwise separated from the maintenance stand. It should be installed before you ascend the stairs to the platform.

The hydraulic system shown in figure 4-14 functions to supply fluid under pressure to the cylinder assembly. Hydraulic fluid from the hand pump (B) goes through the hose (A) to the lower end of the cylinder (F). Pumping the hand pump causes the cylinder assembly to extend. The bypass valve (C), when in the closed position, traps the hydraulic fluid pressure in the cylinder. When the bypass valve is opened, fluid in the cylinder bypasses the hand pump and returns to the reservoir (E). This causes the cylinder to retract. The speed of retraction is controlled by the amount of bypass valve opening. The suction port of the hand pump has a protective strainer (D). This strainer prevents particles from entering the pump.

The stair support assembly consists of two oblong box sections made of welded steel tubing. These two sections are attached by pivot pins to the base assembly at the bottom. The platform is also



42-292

- A. Connecting hose
- B. Hand pump
- C. Bypass valve
- D. Strainer
- E. Reservoir
- F. Cylinder assembly

Figure 4-14. B-1 stand hydraulic system.

attached to these sections by pivot pins. The stairs are mounted between these two sections. They remain parallel to the base at all platform levels. The stair handrail and posts are hinged at both connections at the top to the handrails parallel to the stair support frames at all times.

The work platform is mounted on the upper structure of the stair support assembly. It is approximately 4 feet square. It is made of 1-inch plywood and covered with dimpled sheet metal panels. The platform is bolted to the upper structure and supported by steel channels. This enables it to sustain a static load of 1500 pounds. However, the platform should never be raised when it is carrying a load greater than 500 pounds.

Type B-2 maintenance stand. The type B-2 maintenance stand, as shown in figure 4-15, has a stand permanently mounted on a base extension structure of fixed height. This extension base fabricated of angle iron and steel tubing is 10 feet in height. This arrangement results in a maintenance stand which has a base structure of fixed height, and an upper stair structure and work platform which is hydraulically varied in height. Thus, the B-2 stand is suited for performing maintenance work and inspection of such components as aircraft vertical stabilizers and rudders that often extend to great heights above the ground level.

The base of the B-2 lower stand is constructed of four angle irons connected to form a rectangle



Figure 4-15. B-2 maintenance stand.

which measures approximately 10 x 14 feet. To make the entire stand portable, four pivot-type casters with individual locking devices are mounted at the corners of the base. Upright structural members of steel tubing are bolted to the rectangular base at each corner. On the top of the upright structural members is attached a small base upon which is mounted the standard stair and platform assembly of the type B-1 stand. A ladder equipped with steel steps and handrails is provided to gain access to the upper portion of the stand. In addition to the structural members described, the base structure also employs steel tie rods to provide added rigidity to the stand. The stand is also equipped with four adjustable screw-type pads which may be used to level and immobilize the unit.

The hydraulic system units, including the hydraulic cylinder lift assembly, are identical to those used on the B-1 stand. The hydraulic system installation varies only that the location of some hydraulic units are changed. However, despite these changes, the operation of the hydraulic system remains unchanged.

Type B-4 maintenance stand. This platform (figure 4-16) is a scissors-type, variable height platform. It is mounted on a caster equipped base. Each wheel has a brake and also can be locked at each 90° position. A hydraulic actuator near the bottom of the platform is used to vary the height of the platform from 3 to 7 feet. A reservoir with a hand pump and control valve is mounted on the

platform near the ladder.

Type B-5 maintenance stand. This platform (figure 4-17) is a scissors-type, variable height platform, mounted on a long-legged caster-equipped base. A hydraulic actuating cylinder near the bottom of the platform is used to vary the height of the platform from 7 to 12 feet. A hand pump is used to supply pressure to the actuating cylinder. The hand pump and control valve are mounted on top of the system reservoir. The reservoir is mounted on the platform near the top of the ladder.

CAUTION: This platform should never be raised or lowered while standing on the ladder, or an injury to the feet of personnel may occur.

Type C-1 maintenance stand. This also called the crew chief stand. As you can see figure 4-18, it is a nonadjustable 4 feet high platform. It has wheels on

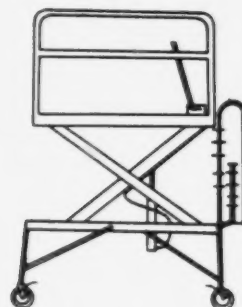


Figure 4-16. B-4 maintenance stand.

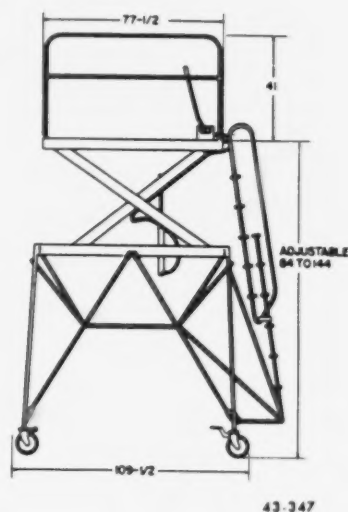
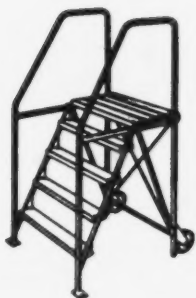
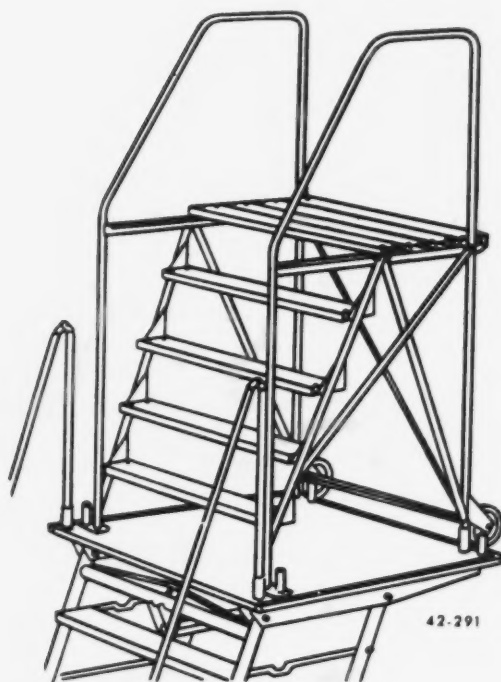


Figure 4-17. B-5 maintenance stand.



43-343

Figure 4-18. C-1 maintenance stand.



42-291

Figure 4-19. C-1 stand, mounted on a B-1 platform.

the back legs so it can be easily moved from one area to another by one man. When C-1 stand is set in position, the wheels leave the ground and the stand sets on its four legs. The C-1 stand can be used independently or it can be installed as an extension on the B-1 and B-2 maintenance stands (see figure 4-19).

Maintenance of Maintenance Stands. No matter how simple a maintenance stand is, sometime during its lifespan it will need some kind of maintenance. This maintenance may consist of just tightening a bolt or the lubrication of the wheel

bearings. As a pneudraulic specialist you will not be tasked with this type of maintenance. You should perform only maintenance of the pneudraulic components required to raise and lower the stands. This consists primarily of the hand pumps, reservoirs, shutoff valves, cylinders, and miscellaneous plumbing. These units will be covered in the next volume, so we will not go into them at this time. Any maintenance performed on the maintenance stands and the associated components should comply with TO procedures if you want good service from these stands.

Exercises (254):

1. Of what principal parts does a stand consist?
2. List five commonly used maintenance stands.
3. How is the B-1 stand similar to the B-2 maintenance stand?
4. How do you lock the hydraulic cylinder used to raise the B-1 and B-2 platform?
5. What are the variable heights of the five maintenance stands?
6. Which of the maintenance stands is non-adjustable?
7. What are maintenance stands designed to do?
8. List the basic components of the maintenance stand hydraulic systems discussed.
9. What precaution should be taken when you raise or lower a scissors-type maintenance stand?

10. The C-1 maintenance stand is sometimes called a _____ stand.

11. List two ways the C-1 stand may be used.

12. Specify the use made of the B-2 maintenance stand.

servicing carts for servicing the pneumatic systems. Also there are units for servicing the oil and hydraulic systems of the aircraft. This section is on the portable servicing carts that can be used to service the hydraulic and pneumatic systems on the aircraft.

255. State the purpose of the air/nitrogen servicing cart, and specify the operational procedures and safety precautions required while it is in use.

4-3. Servicing Carts.

Every time you need gas for your car or air for your tires you usually take it to the filling station. This is a simple maneuver; just get in the car and drive it there. But for aircraft, this operation is not so simple. To service an aircraft, the air force has fuel trucks to service the fuel tanks and pneumatic

Nitrogen Servicing Cart (MD-3). This unit is designed to service the high-pressure air or nitrogen systems of aircraft. It accomplishes this function by transporting six standard commercial-type compressed gas cylinders to the aircraft location. The trailer, figure 4-20, consists of a welded frame mounted on a two-wheel rear axle with a swivel caster wheel located at the front. The trailer has a two connection in the front. A hand-operated brake



Figure 4-20. Nitrogen servicing trailer.

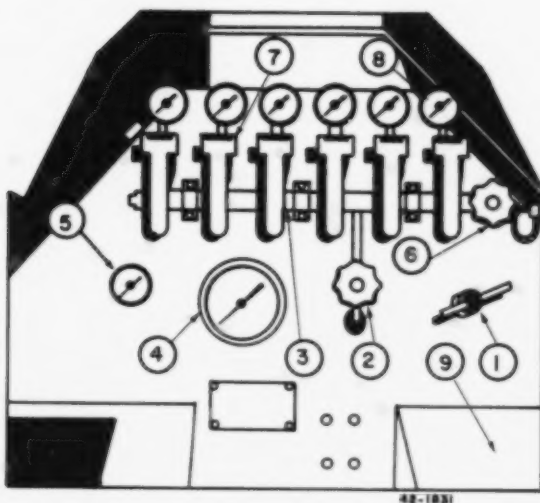


Figure 4-21. Controls on nitrogen servicing trailer.

system is used to apply the brakes on the rear wheels. The two boxes up front are used for storage of hoses and tools. The cylinders themselves are capable of being charged to 3500 psi each. The cylinders may be removed from the trailer and replaced or they may be recharged through the system while mounted on the trailer. A purifier is used to filter out and eliminate moisture and foreign material from the air or nitrogen supplied from the cylinders. The controls on the front of the trailer are used to direct and control the flow of gas to and from the storage cylinders. Refer to figure 4-21 as we briefly talk about these controls. The regulator (1) regulates the pressure from the cylinders. It has two gauges (4 and 5) attached to it. Gauge (5) indicates the pressure going to the regulator, and gauge (4) indicates the outlet pressure from the regulator. The shutoff valve (2) controls the flow of gas from the manifold (3) to the regulator. The six gauges (8) indicate the pressure of the gas in each individual cylinder. The cam lever valves (7) release compressed gas from the cylinders to the manifold. Valve (6) is used for recharging the cylinders when they are empty. The air servicing valve (9) will be talked about later.

Servicing instructions. Refer to figure 4-22 as we go through the servicing procedure. Prior to

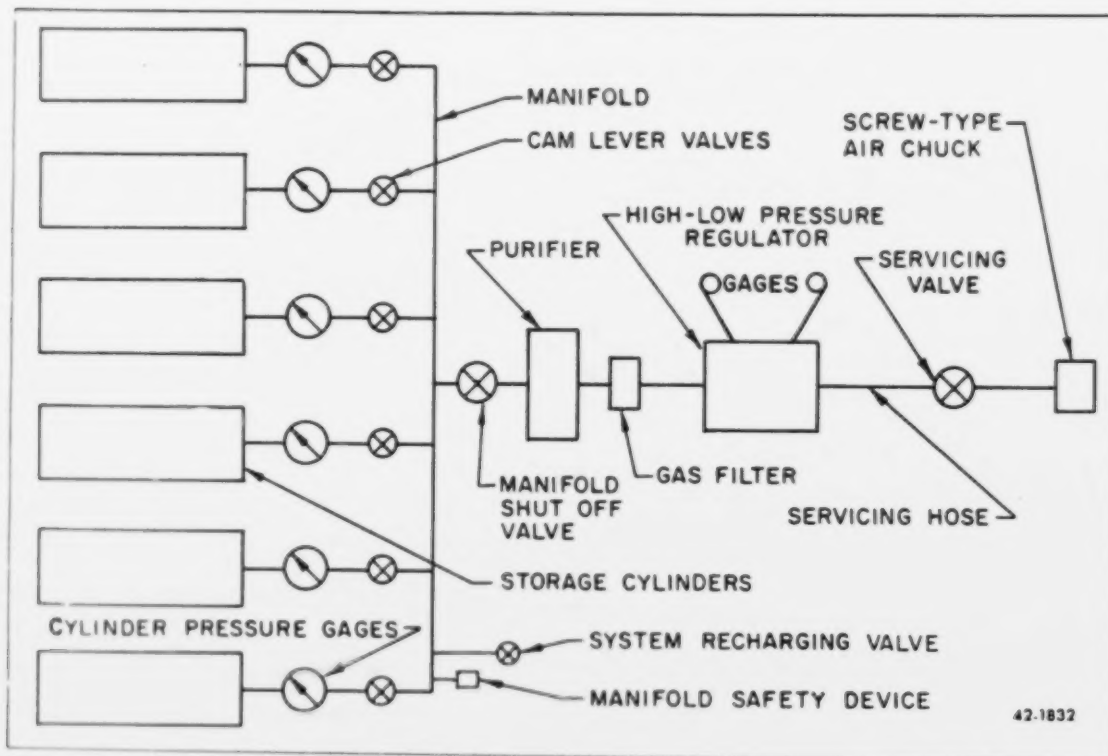


Figure 4-22. Nitrogen servicing trailer schematic.

charging a system with this cart make sure that all six cam lever valves are closed. The system recharging valve and the servicing hose valve should also be closed, and the regulator set for no flow by turning the tee handle counterclockwise. Now, determine the pressure of the system to be charged. Once you have done this, check the six cylinder pressure gauges and find the one with the lowest pressure, but yet higher than the amount you want to service. Open the lever-operated valve of the cylinder with this pressure. **WARNING:** Never have more than one lever-operated valve open at any one time when charging. Now open the manifold shutoff valve slowly. This allows the compressed gas from the cylinders to flow through the cam lever valves, manifold shutoff valve, purifier, filter, and to the air pressure regulator. This pressure will be shown on the left gauge of the regulator. In order to send pressure to the servicing valve, the regulator must be turned clockwise until the desired pressure is shown on the right gauge of the regulator. Should the pressure get higher than the desired delivery pressure, the pressure can be lowered by turning the regulator counterclockwise until the desired delivery pressure is reached. Before connecting the air chuck, inspect the connection and chuck for dirt or grease. Crack the servicing

valve slightly to blow out any dirt that may be in the line prior to making the connection. Close the servicing valve tightly. Make the connection, checking to be sure it is tight. **CAUTION:** The charging hose should not be stretched to reach a connection. Move the trailer if the hose does not reach the connection. The servicing hose must never be under tension when charging. Now, open the servicing valve slowly. The compressed gas should flow to the system requiring servicing. After the system has been charged, close the servicing valve tightly. Next loosen the chuck connection slightly to bleed the trapped air or nitrogen out of the line, then disconnect the chuck completely. Unless additional systems are to be serviced immediately, bleed the pressure out of the system by closing the lever operated valve and opening the servicing valve. After the system has been bled, shut the system down by closing both the manifold shutoff valve and servicing valve, and by turning the regulator tee handle counterclockwise.

Exercises (255):

1. What is the purpose of the air/nitrogen servicing trailer?

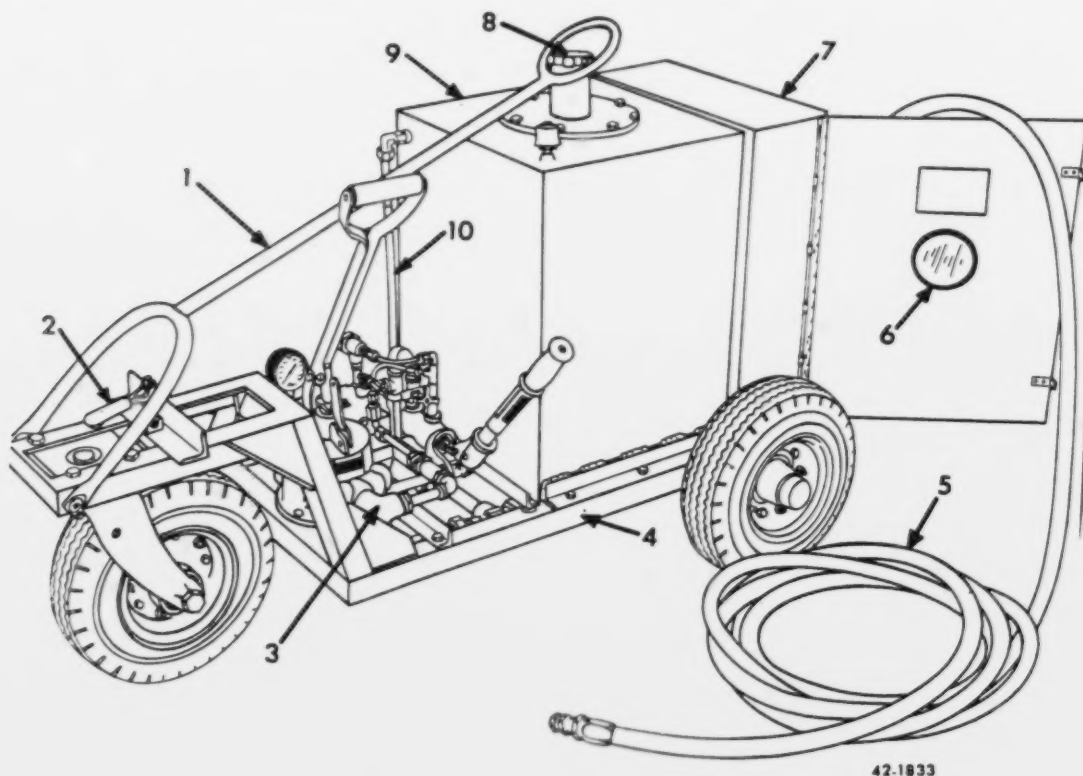


Figure 4-23. Hydraulic servicing cart.

2. What separates the cylinders from the common manifold on the air nitrogen servicing trailer?
3. What would you do if the hose is stretched tight when connecting the servicing cart to the aircraft system?
4. How many lever-operated valves should be open when servicing an aircraft system?
5. What are the two gauges on the regulator for?
6. Why should the servicing hose be slowly disconnected from the aircraft system?
7. What should be done if dirt is noticed in the servicing hose?
8. What cylinder in the servicing trailer should be used to service the aircraft system?
9. How would you turn the regulator to decrease the delivery pressure?
10. What is the purifier used for?

256. Specify the constructional and operational features of a hydraulic servicing cart.

Hydraulic Servicing Cart. Figure 4-23 shows a typical hydraulic servicing cart. It serves as a mobile maintenance unit for the servicing and bleeding of aircraft systems and components. This unit is mounted on three pneumatic tires, with a handle (1) for towing. The brake (2) prevents movement of the cart when applied, especially when parking the trailer on inclines. The hose (5) and tool storage box (7) is located at the rear of the unit and houses the hose when not in use. Inside the hose storage box is a place for coiling the hose, plus a tray for convenient retention of tools, fittings, and accessories pertinent to the operation of the unit. The reservoir (9) is capable of holding 19 gallons of fluid, with a sight glass tube (10) which indicates the fluid level. A reservoir filler cap (8) is located on top of the reservoir for easy servicing. The pumping assembly (3) contains two pumps, both of which draw fluid from the same reservoir. Now that you understand the basic construction of the servicing cart we will describe the operation. Refer to figure 4-24. In this schematic we will show you how simple this operation can be. Notice the two pumps; the low-pressure pump provides large volume displacement, while the high-pressure pump allows application of pressure up to 3000 psi. Both pumping systems are protected from overpressurization by a relief valve in their respective discharge lines. When pressure in either system exceeds the relief valve setting, the fluid is routed through the suction manifold to return to the reservoir. The pumps send fluid to a common pressure manifold, then out through a 5-micron filter assembly. The filter assembly will filter the fluid prior to flowing through the 25-foot hose, and into the system or component being serviced. Any pressure that builds up in the pressure

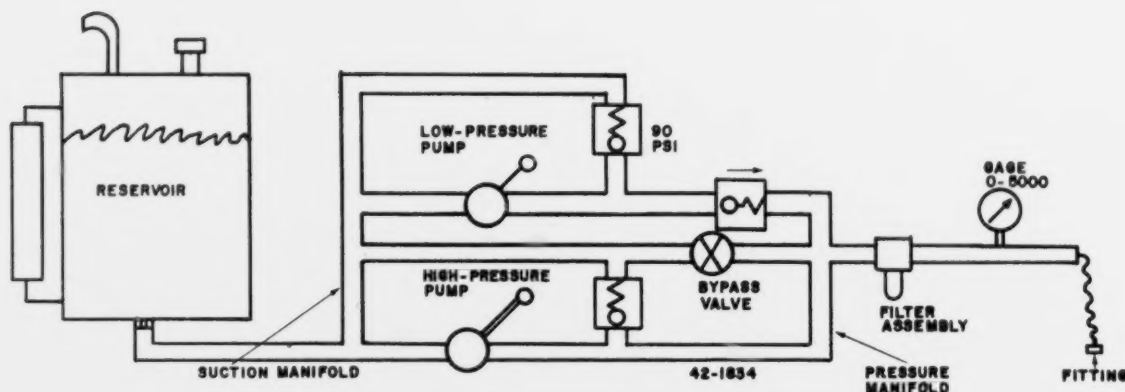


Figure 4-24. Hydraulic servicing cart schematic.

manifold will be read on the 0-5000-psi pressure gauge which is downstream of the filter assembly. The manual bypass valve when opened, connects the suction and pressure manifolds, allowing for bleeding of the unit plus the dumping of the pressure in the pressure manifold. A check valve prevents overpressurizing the low-pressure pumping system when the high-pressure pump is in use. Since a variety of Air Force aircraft utilize different size fittings on the reservoir servicing inlets, no standard size disconnect is provided on the unit. Each activity must provide the particular disconnect needed. Some form of cap or plug must be used to prevent the possibility of contamination when the servicing cart is not being used. To operate the cart, simply hook the fitting (quick disconnect) to the aircraft or component to be serviced; close the manual bypass valve; then pump either the low-pressure pump or the high-pressure pump until you have serviced the system or component. To release the pressure in the pressure manifold, just open the bypass valve. This will route the fluid from the pressure manifold to the return manifold.

Exercises (256):

1. What is the purpose of the 5-micron filter assembly?

2. What prevents the high-pressure pump system from entering and damaging the low-pressure system?
3. Where is the hose stored when not in use?
4. If pressure exceeds the relief valve setting of either the high-pressure or low-pressure pump, what happens?
5. If you wanted to service a large component with fluid, which pump system would be best suited to accomplish this task faster?
6. Why is the servicing fitting on the end of the hose capped or plugged when not in use?

Powered Aerospace Ground Equipment

POWERED AEROSPACE ground equipment (AGE) continues to be important by furnishing power for the ground operation and testing of systems and components installed on aircraft. In many instances you as a pneumatic mechanic will be required to operate this equipment in order to troubleshoot and perform operational checks. The possibility of you coming in contact with AGE is very high because all bases use it. These facts, make it important that you familiarize yourself with the operation, inspection provisions, and safety precautions that pertain to powered AGE. The material contained in this chapter will provide you with information on the components, operation, inspection provisions, and safety precautions of this powered AGE. We have selected typical powered AGE, a portable hydraulic test stand, an air compressor, and a generator set.

5-1. Hydraulic Test Stands

There are many types and models of hydraulic test stands built by different manufacturers for the Air Force. These test stands are available with one, two, or three pressure output systems. They are driven by electric motors and gasoline engines. In this chapter we cover a dual-system test stand that is trailer-mounted and driven by a gasoline engine. (See figure 5-1.) This mobile unit is designed for use on aircraft remote from the electrical power commonly found in the typical hangar.

A hydraulic test stand determines accurately the performance and operating characteristics of aircraft hydraulic systems. It is used in place of the aircraft engine to provide pressurized hydraulic fluid to operate and test all of the hydraulic devices and controls of the aircraft. Another way to say this is that power is transmitted by fluid from a source (motor- or engine-driven pump) to an aircraft system.

In this section of your CDC we will use the MJ-2A as our representative unit. Keep in mind that the systems and components discussed are representative of most hydraulic systems. The knowledge gained in this chapter may be easily applied to other hydraulic systems.

The hydraulic system of the MJ-2A consists of two completely independent high-pressure systems.

These systems are alike in every respect and may be operated simultaneously from two identical control panels. The two systems may also be manifolded (connected together) into a single output.

The hydraulic system of the MJ-2A is quite complex. It may, however, be subdivided into a number of subsystems. We discuss, separately, each subsystem, its components, and its operation.

257. Specify the purpose and operating principles of the fill and bleed system.

Fill and Bleed System Components. The hydraulic test stand uses an engine-driven pump to apply pressure to a fluid. Since liquids are considered as incompressible, the pressure is transmitted through the fluid to the aircraft system. For a smooth, even flow of fluid through the system to occur, the systems must be free of any entrapped air. The fill and bleed system is incorporated into the test stand to enable the operator to purge the air from the system prior to operation.

Figure 5-2 is an illustration of part of the hydraulic system of the MJ-2A hydraulic test stand. You will recall that the unit has two identical high-pressure systems. For simplicity, only one of the systems is shown. The other system, which has been omitted from the top of the diagram, will have the same components and will operate in the same manner.

The dark bordered areas on figure 5-2 illustrate both the supply system which is simply the reservoir (1) and the fill system. The "bleed" portion of the fill and bleed system can actually be considered as part of the low-pressure system. For this reason the filter bleed valve is not included in the area shown as the fill system.

Fill pump. The fill pump (item 2 of figure 5-2) is a two-gear positive displacement pump. It is driven by a 24-volt DC motor. The purpose of the fill pump is to supply the pressure necessary to force fluid from the reservoir to all lines and components of the test stand.

Fill system filters. The fill system incorporates two filters (3) that clean the fluid before it enters

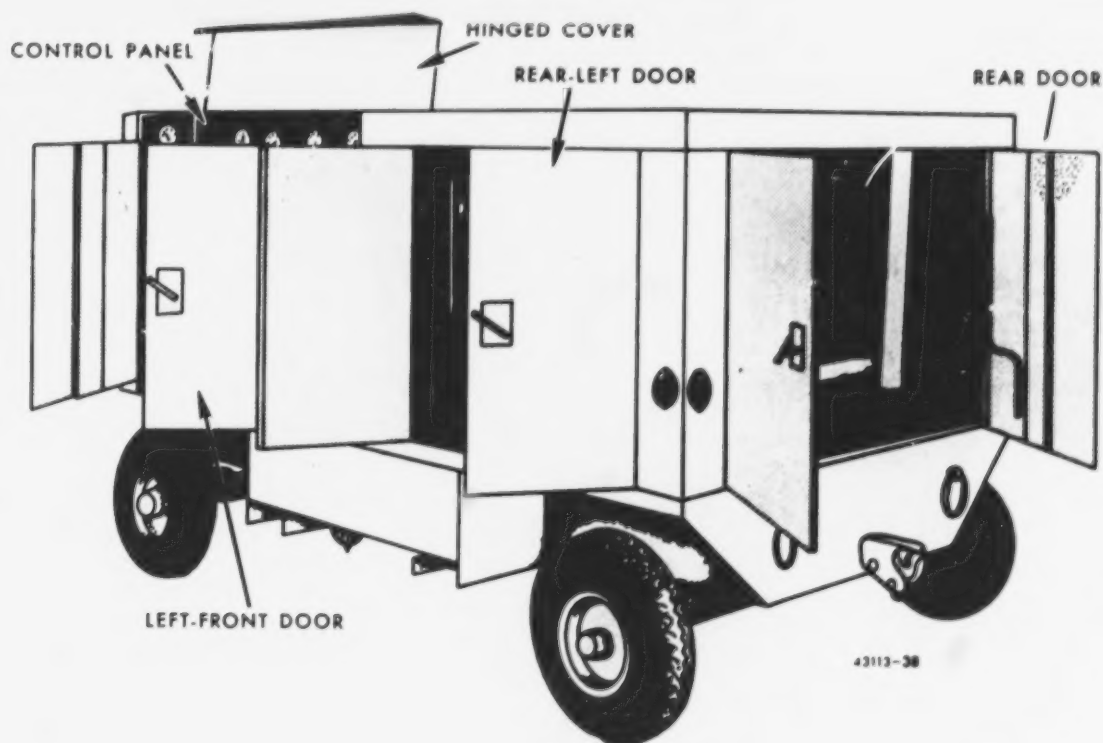


Figure 5-1. Hydraulic test stand (portable).

the main system and components. The initial filtering is provided by the top filter (3) in figure 5-2. This filter removes most of the dirt and contaminating particles from the fluid. Final filtering is provided by the second filter which traps many of the contaminating particles which were small enough to pass through the first filter.

Filter bypass (relief) valve. The filter bypass valve (4) is connected from the inlet side of the filters to the outlet side. It is an adjustable relief valve set to open at approximately 40 psi. When the filters become clogged, pressure will drop at the outlet side. If this drop is greater than 40 psi, the relief valve will open to allow fluid to bypass the filters. Any dirt that should happen to bypass the filters will be trapped by other filters in the remaining systems.

Duplex gauge. The duplex gauge (5) is a dual indicating gauge that shows the filter inlet and outlet pressures. You are not actually concerned with the reading of the two pointers. It is the difference between the two pointers that is most important. A large pressure differential indicates that one or both filters are dirty and should have new filter elements installed.

Push-to-fill valves. The fill system incorporates two push-to-fill valves (6); one for each hydraulic

system on the unit. The valves normally allow fluid to flow from the fill pump (2) back to the reservoir (1). When the fill valve button on the control panel is depressed, the fluid is directed into the appropriate system. You should remember that the valve for system #2 will override the valve for system #1. That is, if both valves are depressed at the same time, only system #2 will fill.

Adjustable relief valves. The output pressures to each system are controlled by an adjustable relief valve (7) in the fill system. The relief valves are manually adjustable from 0 to 140 psi. The pressure in each system is controlled by bypassing some of the fill pump output back to the reservoir. You should remember that these relief valves control only system pressure during filling.

Check valve. The output fluid from the fill system passes through a check valve (8) before entering the system. One check is located in the output line to each system. The check valve contains a spring-loaded ball that allows fluid to flow in the direction of the arrow shown on the valve body. During operation, the check valve prevents fluid from returning to the fill system.

Fill System Operation. The operation of the fill system begins when the fill pump switch is placed in the ON position. The fill pump (2) directs fluid

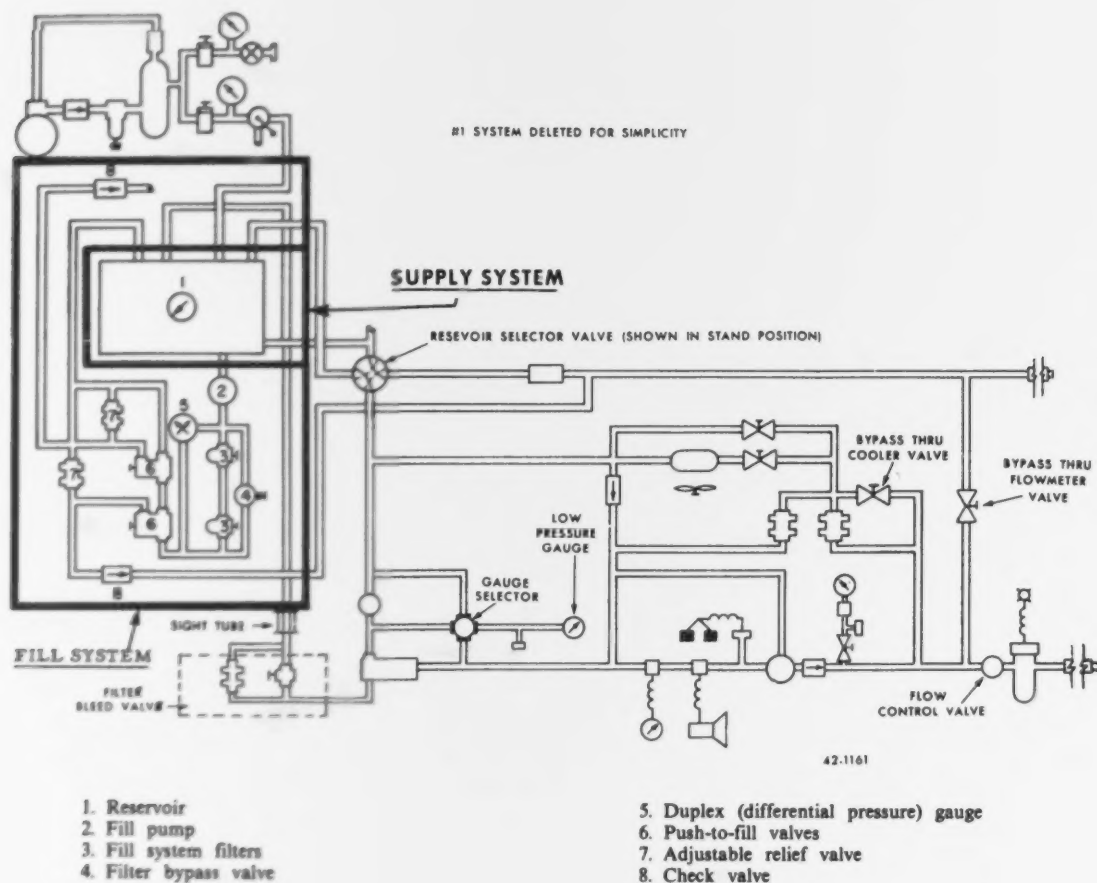


Figure 5-2. Fill and bleed system (MJ-2A).

through the filter (3) and the push-to-fill valves (6) back to the reservoir. The duplex gauge will now indicate the differential pressure across the filters.

When you are ready to fill the system, you must place the reservoir selector valve in the **EXTERNAL** position. Fluid will follow the path through the valve (9) indicated by the dashed lines in the external position; the solid lines show the valve in the **STAND** position. If the reservoir selector valve is left in the **STAND** position during filling, the fluid will simply pass back to the reservoir. No pressure will be developed, and the system will not fill.

After the reservoir selector valve has been placed in the **EXTERNAL** position, you must open both the bypass through the flowmeter valve and the bypass through the cooler valve. The flow control valve must be closed. Place the low-pressure gauge selector valve in the **FILTER INLET** position. The #2 system is now ready for filling.

With the fill pump operating, you must depress the #2 system fill valve (6). This stops the fluid flow

to the #1 fill valve and directs fluid into the lines and components of the #2 system. While holding the fill valve open, adjust the pressure relief valve (7) by turning it clockwise until the low-pressure gauge indicates 15 to 20 psi. Next, you must depress the filter bleed valve while observing the flow of fluid through the sight tube on the control panel. At first you should notice bubbles of air in the fluid. The system pressure will drop to 0 psi when the filter bleed valve is opened.

You must repeat the pressurizing and bleeding operation until a solid column of fluid (no bubbles) can be seen in the sight tube. Once you have filled the #2 system, and have purged it of all air, you must repeat the complete operation for the #1 system. This is only necessary when you anticipate the operation of both systems. After completion of the filling operation, you should leave pressure on the system in order to check for possible leaks in the lines, fittings, and components. Finally, place the fill pump switch in the **OFF** position.

Exercises (257):

1. What is the purpose of the fill system of the hydraulic test stand?
2. How is the fill pump driven?
3. What is indicated if the pointers on the duplex gauge are within a few psi of each other?
4. If both fill valves are pushed at the same time, what will happen?
5. When does the operation of the fill system begin?
6. Why should you leave pressure on the system after you have completed a filling operation?
7. How often should you repeat the pressurizing and bleeding operation?
8. What would happen if the reservoir selector valve was left in the STAND position during a filling operation?

258. State the purpose and operating principles of the low-pressure system and components.

Low-pressure System Components. The low-pressure system of the hydraulic test stand is used to supply a constant flow of fluid to the main pump. The main (high-pressure) pump is lubricated and cooled by the fluid it pumps. Due to its design, the high-pressure pump does not develop a suction pressure as do most pumps. If fluid is not forced into the pump under a low pressure, the pump will rapidly run dry and will be internally damaged. The purpose of the low-pressure system is to insure a constant flow of fluid into the body of the high-pressure pump.

Figure 5-3 illustrates the same systems and components of the hydraulic test stand as shown in figure 5-2. In figure 5-3, however, the dark bordered area includes the components of the low-

pressure system. Once again, system #1 is deleted from the figure, but will also contain the same components.

Reservoir selector valve. The reservoir selector valve (9) is a two-position, four-way valve. As its name implies, it provides the operator with a means of selecting the reservoir that will supply fluid to the low-pressure system. When placed in the STAND position, shown by the solid lines, the fluid flows from the test stand reservoir to the low pressure pump (10). In the EXTERNAL position, fluid from the aircraft return line is recirculated through the system, pressurized, filtered, and directed back to the aircraft through the pressure lines.

Low-pressure pump. The low-pressure pump (10), also known as the boost-pressure pump, is a sliding vane, rotary pump that provides a constant volume of fluid to the high-pressure pump. It has a rated capacity of 35 gallons per minute while the maximum output of the high-pressure pump is only 30 gpm.

Low-pressure gauge selector valve. The low-pressure gauge selector valve (11) provides you with a means of using a single gauge to indicate boost pump inlet, filter inlet, and filter outlet pressures. The valve is a three-way, four-position valve. The fourth position is a gauge shutoff used when calibrating the low-pressure gauge. During normal operation, the valve is usually left in either the filter inlet or filter outlet position.

Low-pressure gauge. The low-pressure gauge (13) is capable of indicating positive pressure from 0 to 300 psi or negative (suction) pressure from 0 to 30 Hg (inches of mercury). The gauge will indicate the pressure of the line to which it is connected by the gauge selector valve. When you are measuring and comparing filter inlet and outlet pressures, a significant pressure differential indicates that the low-pressure filters are dirty and should be changed.

Low-pressure filter assembly. Fluid leaving the low-pressure pump must pass through the low-pressure filters (14) before entering the high-pressure system. The filter assembly consists of three paper cellulose elements in one housing. Because of size and vertical position of the assembly on the unit, any air remaining in the system becomes entrapped in the filter housing.

Filter bleed valve. The air which collects in the low-pressure system is bled off and directed back to the reservoir by the filter bleed valve (15). This is the same valve that was used to bleed the system during the filling operation.

Fluid sight tube. The presence of air in the system is detected by visually observing the fluid passing through the fluid sight tube (16). This glass tube is located on the system control panel. You should always check the fluid condition prior to operating the high-pressure system. The fluid must be clean and free of air bubbles. Decontaminated

fluid should be clear (of impurities) and bright red in color.

Thermal relief valve. The filter bleed valve (15) incorporates a thermal expansion relief valve (17) in the bleed valve body. When the unit is shutdown, heat will cause the fluid to expand and build up pressure in the system. There is a definite possibility that this pressure could break the glass flowmeter. The thermal relief valve will relieve this buildup of pressure, thereby protecting all devices in the system, including the flowmeter.

Thermal sensing bulb and temperature gauge. The temperature sensing bulb (18) and the temperature gauge (19) are, in fact, a single unit. The bulb is a thermal expansion bulb filled with a gas. Any change in fluid temperature causes a corresponding change in gas pressure in the bulb. The bulb is connected through a capillary tube to the temperature gauge. The gauge changes the pressure due to expansion into a corresponding temperature indication.

Thermal switch. The thermal switch (20) completes an electrical circuit to the warning horn when the fluid temperature reaches a predetermined temperature. Once the horn sounds, it will continue to operate until the temperature of the fluid is reduced.

Boost pressure switch. The boost pressure switch (21) is incorporated into the low-pressure system to prevent engine operation if there is a loss of low pressure to the main pump. The switch contains one set of normally closed contacts. These contacts are held open by boost pressure. Upon closing, the switch completes the electrical circuit to the carburetor solenoids on the engine. Energizing the carburetor solenoids stops fuel flow to the engine.

Check valve. The low-pressure system check valve (23) prevents the flow of low-pressure fluid back to the boost pump (10). During filling operation, fluid will not readily pass through the boost pump to the low pressure filters (14). The addition of the check valve allows fluid to fill the

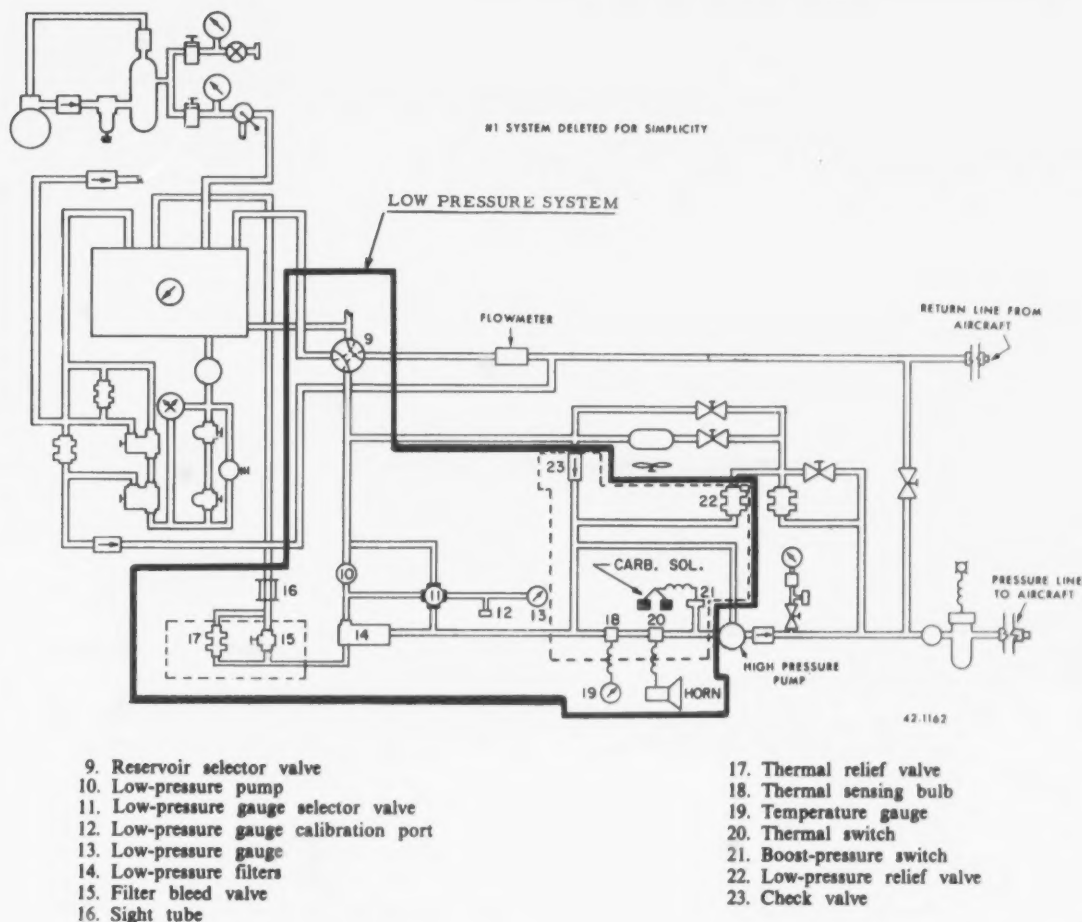


Figure 5-3. Low-pressure system (MJ-2A).

lines of the low-pressure system, including the low-pressure filter. During operation, the check valve prevents the loss of boost pressure back to the inlet side of the boost pump. The check valve is located in the low-pressure manifold, near the boost pump.

Relief valve. The final component in the low-pressure system is the pressure relief valve (22). This manually adjustable valve is used to regulate the pressure in the low-pressure system. Pressure is regulated by bypassing excess fluid back to the inlet side of the boost pump (10).

Low-Pressure System Operation. After the systems have been filled and the air is bled off, you are ready to run the engine. When the engine starts, the boost pump (10) draws fluid from either the stand reservoir or the aircraft reservoir, depending on the position of the reservoir selector valve (9). Let's assume that the selector is in the STAND position, as shown in figure 5-3.

The boost pump develops a suction pressure and draws fluid into itself. The fluid is pressurized to about 40 psi and is forced into the low-pressure filter. The filter partially cleans the fluid. Any air which is still in the system rises to the top of the filter housing. By depressing the bleed valve (15) on the control panel, the entrapped air may be returned to the reservoir. You should observe the sight tube and bleed the filters until a solid column of fluid can be seen.

The low-pressure gauge selector valve (11) has three positions; **BOOST PUMP SUCTION**, **FILTER INLET**, and **FILTER OUTLET**. You can check the operation of the boost pump by placing the low-pressure gauge selector valve in the **PUMP INLET** position. This will give you the amount of pump suction. By placing the selector in the **FILTER INLET** position it will give the pump pressure. You can see in figure 5-3 that the inlet pressure to the filters is the same as the outlet pressure of the boost pump. Inlet or suction pressure is indicated on the gauge in inches of mercury (Hg). Outlet pressure is measured in pounds per square inch (psi).

The condition of the filters can also be determined by measuring and comparing the filter inlet and outlet pressures. The difference in pressure between the two readings is known as the differential pressure. You must check the unit TO to determine the maximum allowable pressure drop for the filters of any system.

From the low-pressure filters fluid flows through the low-pressure manifold to the high-pressure pump. The thermal sensing bulb (18) and temperature gauge assembly (19) provide a means of monitoring fluid temperature during operation. Excessive temperature will cause the thermal switch (20) to close, completing the circuit to the warning horn. When the horn sounds, fluid flow to the aircraft should be stopped until the fluid can be cooled below the maximum allowable limit. The method used to cool the fluid will be discussed later.

If, at any time during operation, the boost pump pressure should drop below a predetermined level, the boost pump pressure switch will close. This completes the circuit to the carburetor solenoids and stops engine operation. The automatic shutdown feature is provided to protect the high-pressure pumps from a loss of inlet pressure.

Exercises (258):

1. What type pump is used for the low-pressure (boost) pump?
2. What is the purpose of the low-pressure system?
3. How is the boost pump driven?
4. What is the purpose of the thermal relief valve incorporated into the body of the filter bleed valve?
5. How is pressure regulated?
6. From where does the boost pump draw fluid when the reservoir selector valve is in the STAND position?
7. Why should the warning horn sound?
8. What would occur if the boost pump pressure dropped below a predetermined level and closed the boost pump pressure switch contacts which completed a circuit to the carburetor solenoids?
9. What is the purpose of the low-pressure system check valve?
10. How is air in the system detected visually?

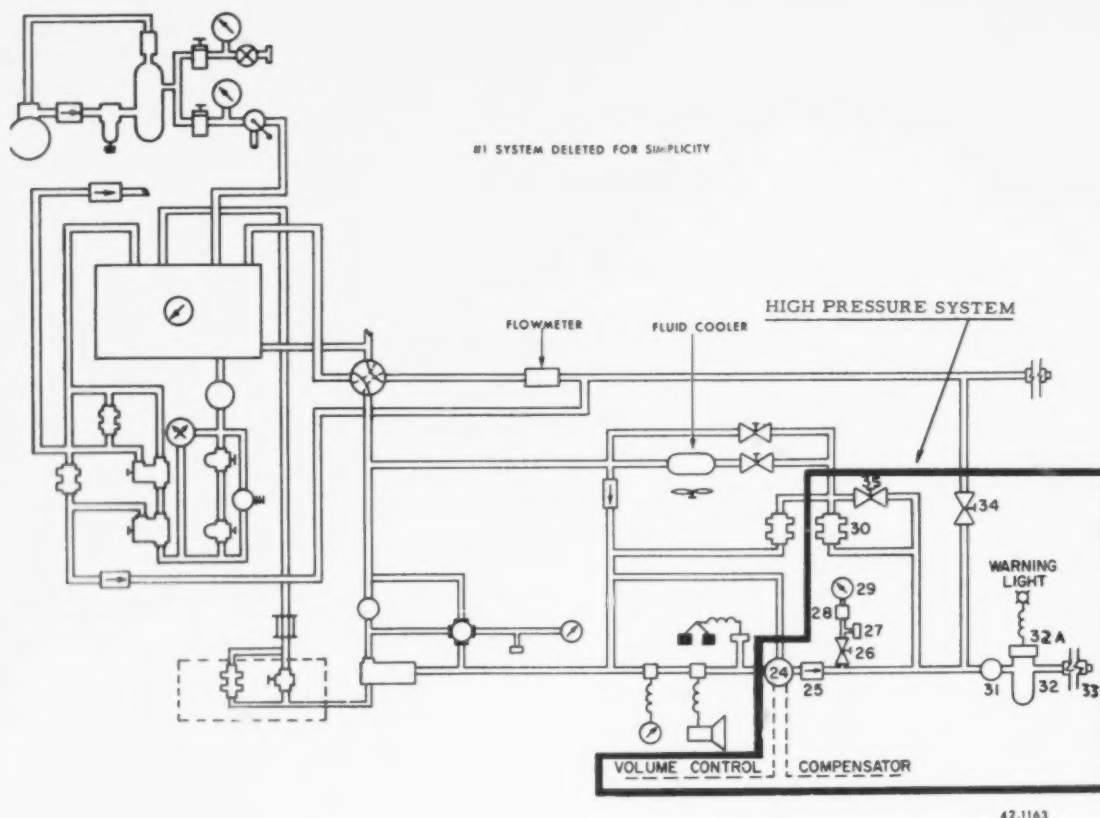
259. Specify the purpose and operating principles of the high-pressure system and components.

High-Pressure System and Components. The purpose of the high-pressure system of the MJ-2A hydraulic test stand is to provide fluid to the aircraft system at a controlled volume and pressure. This pressurized fluid is used to duplicate the output of the aircraft's engine-driven hydraulic pumps. Through the use of the hydraulic test stand, the complete aircraft hydraulic system can be serviced, tested, and inspected without the need to operate the aircraft engines. The high-pressure system is outlined in figure 5-4. You will notice that a volume control and pressure compensator have been shown with mechanical connections to the high-pressure pump. These two components are not actually a part of the flow system. Both of them are

control devices used to maintain the output pressure of the high-pressure pump. You should refer to figure 5-4 as you read the following explanation of the system components.

High-pressure pump. The high-pressure pump (24) is a variable volume pump capable of providing a maximum volume of 30 gpm at 3000 psi. If higher pressure is required, the volume may be reduced to 15 gpm, and the maximum pressure can then be adjusted up to 5000 psi.

In order to adjust the output volume of the HP pump, the bypass through flowmeter valve (item 34 of figure 5-4) must be open, this will allow the entire volume output of the pump to pass through the flowmeter. The flow control valve (item 31) and the bypass through cooler valve (35) must also be closed.



- 24. High-pressure pump
- 25. High-pressure check valve
- 26. HP gauge shutoff valve
- 27. HP gauge calibration port
- 28. Vibration dampener
- 29. HP gauge
- 30. HP relief valve

- 31. Flow control valve
- 32. HP filters
- 32A. Differential pressure switch
- 33. Outlet pressure connection
- 34. Bypass through flowmeter valve
- 35. Bypass through cooler valve

Figure 5-4. High-pressure system (MJ-2A).

It is important for you to note that the setting of the volume control will depend on the requirements established in the aircraft TO. Each task to be performed on the aircraft hydraulic system will state the flow to which the volume control must be set. When you perform an inspection of the hydraulic test stand, the volume control is normally set to approximately 30 gallons per minute. Once you have established the volume output of the pump, you must adjust the pressure compensator in order to obtain a controlled pressure output at the present volume.

Pressure compensator control. In order to set the compensator, you must close both the bypass through flowmeter and the bypass through cooler valves (items 34 and 35, respectively, in figure 5-4). At this point the entire volume output will pass through the relief valve (item 30), and will be returned to the inlet side of the pump. For purposes of this discussion, assume that the relief valve is already set at 3300 psi, and that the compensator is set a minimum pressure. Before we adjust the compensator to 3000 psi, let's first discuss its static conditions.

Setting the compensator requires that you first unlock the handwheel locknut by rotating it in a counterclockwise direction. The handwheel is then free to move when turned.

(NOTE: The compensator handle should never be turned to its maximum travel in either direction.)

In order to obtain the desired pump pressure (3000 psi) from the high-pressure pump, we must rotate the handwheel in a clockwise direction.

We have now seen how the high-pressure pump is adjusted, and how it is controlled by the pressure compensator and volume control. Let's return now to figure 5-4 and learn the purpose of the remaining components of the high-pressure system.

High-pressure check valve. The high-pressure check valve (25) is located in the outlet line of the high-pressure pump. It is a one-way check valve, which prevents a reverse flow to the HP pump.

HP gauge shutoff valve. The gauge shutoff valve (26) is located below and slightly to the side of the high-pressure gauge on the control panel. The valve is used to isolate the gauge during maintenance and calibration of the high-pressure gauge.

HP gauge calibration port. The high-pressure gauge calibration port (27) is used to connect an external source of pressure to the gauge. During calibration, the gauge shutoff valve (26) is closed. A special hand-operated pressure pump, with a calibrated gauge, is connected to the calibration port. When the hand pump is operated, the gauge on the unit is compared and calibrated with the gauge.

Vibration dampener (snubber). The high-pressure gauge is very susceptible to variations in pressure. The gauge is equipped with a vibration dampener (28), which is a calibrated orifice in the fitting to

the gauge. The dampener provides a restriction in the line that reduces the sudden variation in pressure to the gauge. This tends to stabilize the indicator, and provides a suitable gauge reading with only minor pointer fluctuations.

High-pressure gauge. The high-pressure gauge (29) provides a visual indication of the pressure in the high-pressure system. The gauge is capable of indicating pressures from 0 to 6000 psi, with a redline (danger) area from 5000 to 6000 psi. The gauge is located at the top of the system control panel.

High-pressure relief valve. In order to protect the high-pressure system from overpressurization, the system incorporates a pressure relief valve (30). The relief valve, when properly adjusted, bypasses a sufficient quantity of fluid to maintain pressure at its preset level.

Flow control valve. The flow control valve (31) is nothing more than a shutoff valve to the pressure outlet connections. The valve located on the system control panel near the bottom is open when its handle is turned in the full counterclockwise direction.

High-pressure filter. Each system of the MJ-2A hydraulic test stand incorporates a high-pressure filter (32).

Since fluid contamination is one of the major problems in hydraulic systems, the high-pressure filter housing incorporates a differential pressure switch (32A). When the filters become dirty, a difference in pressure develops across the filter. When the differential pressure reaches a predetermined level, the differential pressure switch closes and completes the circuit to the filter warning light. The warning light is located on the control panel, and will continue to glow red until the switch is reset. If the filters are not changed, the light will immediately begin to glow when the flow control valve is again opened.

Outlet pressure connection. Each high-pressure system has a quick disconnect pressure connection (33) in its outlet line. These connections provide a means of rapidly connecting or disconnecting the outlet and return hoses to the aircraft. Each half of the assembly (half on the unit and half on the hose) has a spring-loaded shutoff valve to prevent dirt and other contaminants from entering the system when the hoses are disconnected. When not in use, all connections should be covered with the provided caps.

Bypass through cooler valve. The bypass through cooler valve (35) is a manual shutoff valve for the fluid cooler. When the temperature increases above normal range, the warning horn will sound. The operator must then open the bypass through cooler valve and recycle the fluid through the cooler. The bypass through cooler valve is located near the bottom of the system control panel.

By pass through flowmeter valve. The bypass through flowmeter valve (34) is located near the bottom of the system control panel. It is used only when you are setting the volume control adjustment of the HP pump. During normal testing of aircraft systems, the valve is kept closed. The flowmeter will then indicate the flow in the return line from the aircraft.

High-Pressure System Operation. The operation of the high-pressure system can be divided into two categories: operation for testing and adjustments, and operation on the aircraft.

When the engine is running, the high-pressure pump is turning. If the volume control and compensator are properly adjusted, the fluid is pressurized and forced out through the high-pressure check valve. The high-pressure gauge shutoff valve should be open.

The high-pressure gauge should be providing an indication of the system pressure. If the bypass through cooler valve is opened, fluid will be directed into the temperature control system for cooling. Opening the bypass through flowmeter valve will direct the pump output into the return system. The flowmeter will then indicate the volume output of the HP pump. Now consider an output to the aircraft. This is done by connecting the high-pressure and return hoses to the aircraft. The flow control valve would be opened, then the bypass through a flowmeter valve would be closed. This action would stop the bypassing of fluid, and direct the entire output through the high-pressure filters to the aircraft.

Exercises (259):

1. What is the purpose of the high-pressure system?
2. What type of high-pressure pump is used on the MJ-2A hydraulic test stand?
3. What is the purpose of the pressure compensator?
4. What is the minimum output of the high-pressure pump?
5. How is the high-pressure pump lubricated?

6. Why must the bypass through flowmeter valve be closed in order to set the pressure compensator?
7. How is the output connected to the aircraft?
8. To have a flow of fluid from the test stand to the aircraft, what positions must the flow control valve and the bypass through flowmeter valve be in?

260. Specify the operating principles of the return, temperature control, and pneumatic systems for the hydraulic test stand.

Temperature Control System. Figure 5-5 illustrates the return, temperature control, and pneumatic systems of the MJ-2A hydraulic test stands in the dark bordered areas.

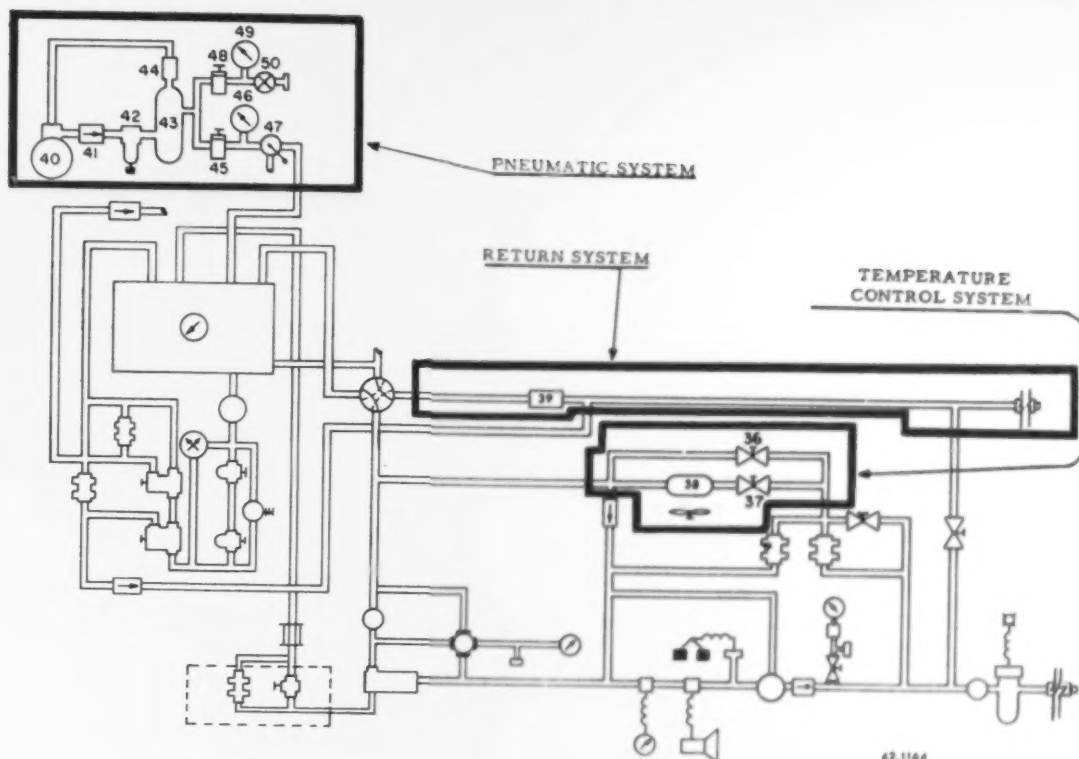
The temperature control system consists of only three components. The purpose of the temperature control system is to cool the fluid in the event of an overtemperature condition. Normal heating of the fluid will occur during operation.

Cooler bypass valve. The cooler bypass valve (36) is simply a shutoff valve used to bypass fluid around the cooler. In areas of extreme cold, the fluid will tend to become more dense and will not readily flow through the system. It is obvious that you would not want to cool fluid that is already too cold. The valve is either opened or closed, depending on climatic conditions.

Cooler shutoff valve. The cooler shutoff valve (37) is identical to the cooler bypass valve in its construction. The shutoff valve is used to open or close the line to the cooler. In the event of an overtemperature condition (if the warning horn sounds), you must open this valve and allow the fluid to cool until the warning horn stops sounding.

It is extremely important that you NEVER close the cooler shutoff valve and the cooler bypass valve at the same time. This will result in high pressure in the lines of the temperature control system. These lines are not capable of withstanding much pressure. If both valves are closed, the resulting high pressure will almost assuredly rupture the lines, and may cause serious injury to the operator. For this reason, you will usually find these valves, and the corresponding valves in the #1 system safety wired in their position.

Fluid cooler. The hydraulic fluid of the MJ-2A is cooled by an automotive-type heat exchanger and cooling fan located at the front of the unit. The heat exchanger is more commonly known as the



- 36. Cooler bypass valve
- 37. Cooler shutoff valve
- 38. Fluid cooler
- 39. Flowmeter
- 40. Air compressor
- 41. Air check valve
- 42. Air filter
- 43. Air receiver

- 44. Pilot unloader valve
- 45. Stand reservoir pressure regulation
- 46. Stand reservoir pressure gauge
- 47. Reservoir pressurization selector valve
- 48. Aircraft reservoir pressure regulator
- 49. Aircraft reservoir pressure gauge
- 50. Aircraft reservoir air shutoff valve

Figure 5-5. Return, temperature control, and pneumatic system (MJ-2a).

fluid cooler (38). It closely resembles the radiator of an automobile. Fluid flowing into the cooler passes through a series of tubes and returns to the inlet side of the low-pressure pump. A series of cooling fins on the tubes extract the heat from the fluid. A large cooling fan is located behind the cooler. It directs a large volume of cooling air through the cooler to remove heat from the system. The cooler is divided into two equal halves; each half cools the fluid for one system. The cooling fan is driven by a drive shaft connected to the engine gearcase. We will see later that the pneumatic system air compressor is also driven through the same shaft.

Fluid Return System. The fluid return system consists of only one component. The purpose of the system is to provide a path for fluid to return to the test stand from the aircraft. If a flow of 10 gallons per minute is directed to the aircraft, the same volume must return to the test stand. This

return flow must pass through the flowmeter (39), which provides a visual indication of the volume. The flowmeter is a calibrated tapered, glass tube. A metal float located inside the tube is raised by the fluid flow. The volume is indicated at the point where the edge of the float points to the indicator scale. Fluid leaving the flowmeter passes through the reservoir selector valve. Depending on the position of the valve, the fluid will either enter the stand reservoir, or will be directed back to the boost (low-pressure) pump. You must remember NEVER to change the position of the reservoir selector valve while the unit is operating. You will cause an instantaneous high pressure in the return system, which may shatter the flowmeter. This could result in flying glass and hydraulic fluid hitting the operator.

Pneumatic System and Components. The MJ-2A hydraulic test stand also incorporates a pneumatic

system. The purpose of the pneumatic system is to provide low-pressure air to the stand and aircraft reservoir. The pneumatic system reduces foaming in both reservoirs. You may think of this as being similar to holding your thumb over the neck of a bottle of carbonated soda. As long as there is pressure in the bottle, very little foam collects at the top of the bottle. As soon as pressure is released, foaming occurs rapidly. In our hydraulic reservoir, the presence of an excessive amount of foam may cause the reservoir to overflow. Even worse, it may cause air to be pumped into the aircraft hydraulic system.

Air compressor. The air compressor (40) is a two-cylinder, single-stage compressor. Each cylinder compresses air and directs it to a common output line. The compressor is driven by a V-belt that connects to a pulley on the cooling fan drive shaft.

Check valve. A check valve (41) is located in the outlet air line from the compressor. During operation, the compressor will unload at a predetermined pressure. Without the check valve, the air pressure in the pneumatic system would be bled off. The check valve prevents reverse flow to the compressor.

Air filter. Once the air has been compressed, it passes through the air filter (42), which consists of a porous, cone-shaped stone. The stone element removes moisture and dirt from the air. If the air were not filtered, the dirt and moisture would eventually find a way into the reservoir. In dusty, humid atmosphere the dirt and moisture would severely contaminate hydraulic fluid. When shutting the unit down, you should always open the moisture drain valve on the bottom of the filter housing. This will drain all air pressure from the system, and will also allow the accumulated moisture to be removed.

Air receiver. The air receiver (43) is a small cylindrical tank located near the low-pressure filters on the right side of the unit. It is used to store the compressed air to be used for pressurizing both the stand reservoir and the aircraft reservoir.

Pilot unloader valve. Once the compressor has built up pressure in the receiver to a predetermined level, the pilot unloader valve (44) allows air pressure to be applied to the compressor unloaders. These unloaders contain a diaphragm-actuated rod that holds the compressor intake valves open. The compressor will not pump any air as long as its intake valves are open. As the receiver pressure drops, the pilot unloader valve will close and drain pressure from the compressor unloaders. The intake valves will be allowed to close, and the compressor will again build up pressure in the receiver until the preset limit is again reached. From the receiver, the air is directed into two parallel paths. One path is to an external air pressure connection connected to the aircraft. The second path is to the test stand reservoir.

Air pressure regulator. The unit's pneumatic system contains two air pressure regulators (45 and 48). Both regulators are located on the bottom of the engine control panel. The stand regulator (45) is mounted on the bottom left, and the aircraft regulator is on the bottom right. Each regulator is a manually adjustable unit that automatically controls air pressure to its respective reservoir. The regulators must always be set in accordance with the applicable aircraft technical order for the test which is being performed.

Pressure gauges. Each output line of the pneumatic system contains a pressure gauge (46 and 49) which is used to monitor air pressure in each reservoir. The stand pressure gauge (46) is capable of measuring pressure from 0 to 60 psi. The aircraft pressure gauge measures pressures up to 200 psi.

Reservoir pressurization selector valve. The reservoir pressurization selector valve (47) is a two-position, three-way valve. Its purpose is to control the pressurization and depressurization of the stand reservoir. When the valve is placed in the pressurized position, regulated air is directed from the regulator into the reservoir. When placed in the VENT position, the pressure in the reservoir is drained off to the atmosphere. In some models of the MJ-2A, the vent position of the valve is labeled "EXHAUST."

Aircraft reservoir air shutoff valve. This shutoff valve (50) is used to control the flow of air to the aircraft reservoir. When the air pressure to the aircraft is not required, this valve must be left in the closed (fully clockwise) position.

Exercises (260):

1. What action must be taken by the operator immediately upon hearing the overtemperature warning horn?
2. Why should the cooler shutoff valve and the cooler bypass valve never be closed at the same time during operation?
3. How is the heat in the fluid removed and dissipated to the atmosphere?
4. Explain why the flowmeter is located in the return system.

How is the pneumatic air compressor driven?

6. What is the purpose for pressurizing the test stand reservoir?
7. What component of the MJ-2A hydraulic test stand controls the maximum air pressure in the air receiver?

261. Name the major areas to be checked during the inspection of the MJ-2A hydraulic test stand.

Inspection Procedures. The service inspection should always begin with a thorough review of the maintenance forms. Once you are satisfied that there are no uncleared discrepancies, examine the exterior frame for any signs of damage. The exterior inspection also includes a check of the tires and brakes. The interior of the MJ-2A is accessible through a number of hinged doors and panels. The interior service inspection should follow an established sequence to insure that nothing is overlooked. The engine should be checked to insure that there are no loose or damaged parts. You should check all wiring for security and damage. The engine and gearcase oil must be checked and serviced as required. You must check the engine for fuel and oil leaks. The air compressor oil level should also be checked. While you are in that area, check the V-belt and the universal joint on the blower fan drive shaft.

The hydraulic system inspection should include a check of all components, lines, and fittings. Frequently, it is difficult to tell whether or not a line, fitting, or component is leaking. A fresh leak will feel oily to the touch and will be bright red in color. An old accumulation of fluid will feel sticky and will appear to be a pink color. If you are in doubt as to whether or not a component is leaking, it is best to run the system with sufficient pressure so as to cause it to leak. However, do not exceed the design pressure of the system in question.

The inspection should continue with a thorough inspection of the instrument and control panels. You should check all gauges for broken glass faces, and all valves and controls for freedom of movement. There should be no excessive looseness in the valves and controls. You must also inspect the valves for signs of leakage. All selector valves must be checked in each of their positions. All switches on the control panel should be turned off.

It is a common error to overlook the hoses used to connect the stand output connections to the aircraft. These hoses carry fluid at high pressures

and preset a particularly hazardous condition. There should be no evidence of damage to the exterior of the hoses. The quick-disconnect fittings must not show any evidence of damaged threads. There should be no leakage from the disconnect couplings.

Exercises (261):

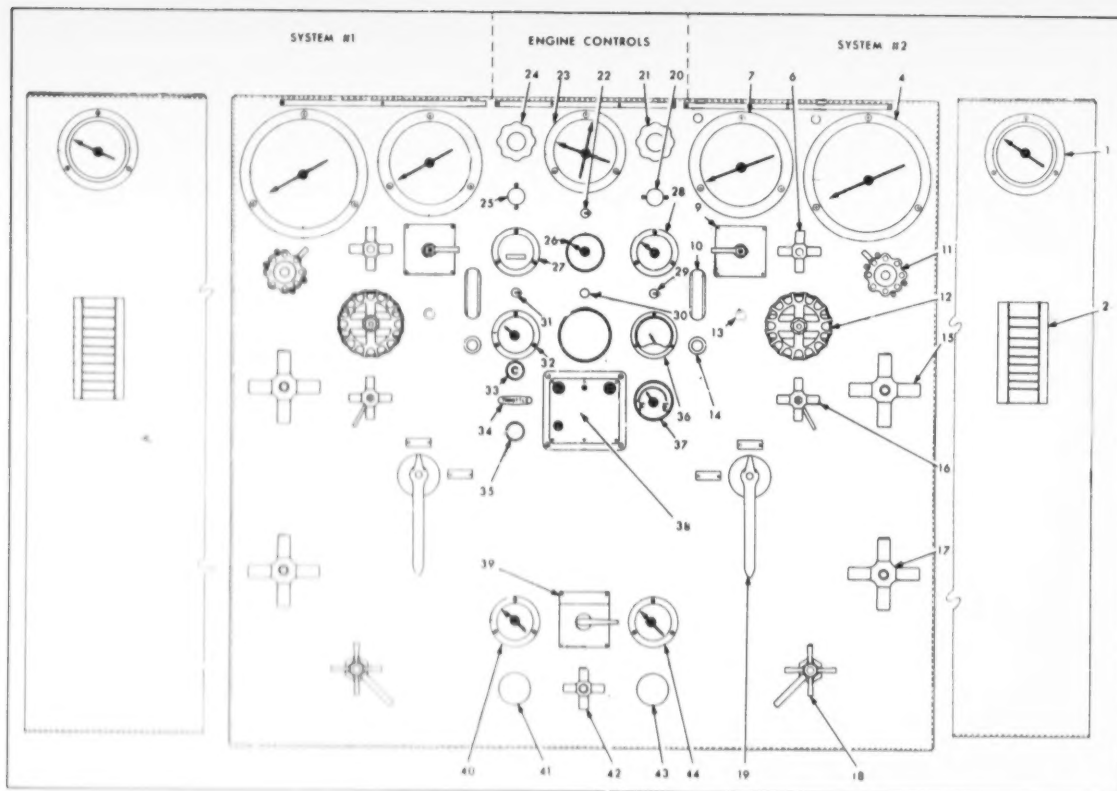
1. What is the first item to be checked when performing a service inspection of the MJ-2A?
2. What is commonly overlooked when performing an inspection of the MJ-2A test stand?
3. How many lubricating oil levels must be checked on the MJ-2A?
4. What checks are made when inspecting the various valves of the instrument and control panel?
5. List the major areas to be covered when inspecting the MJ-2A.

262. Specify operating procedures of the MJ-2A hydraulic test stand.

Operating Procedures. The operation of the MJ-2A is really no more difficult than that of any other piece of equipment. We must, however, perform a number of operations common only to the hydraulic test stand. There are valves to open, valves to close, switches to turn on, and switches to turn off. You are not expected, nor should you attempt to memorize the sequence of operation. We are more interested in knowing why a valve is opened or closed, rather than when to open or close it in a sequence of events.

NOTE: The hydraulic test stand has one additional hazard which is not prevalent in other equipment. There is always the possibility that a line could rupture during operation. The fluid under high pressure can bind you and may even be injected directly into the skin.

Setting up the control panel. Figure 5-6 is an illustration of the instruments and controls used on the MJ-2A. In this figure you will notice that the control panel is divided into three sections: the system #1 panel, system #2 panel, and the engine



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- | | | |
|--------------------------------------|--|---|
| 1. Fluid temperature gauge | 16. Colume control | 31. Starter switch |
| 2. Flowmeter | 17. Bypass through cooler valve | 32. Engine oil pressure gauge |
| 3. Deleted for simplification | 18. HP relief valve | 33. Choke control |
| 4. HP gauge | 19. Reservoir selector valve | 34. Throttle handle |
| 5. Deleted for simplification | 20. Push-to-fill valve (#2 system) | 35. Starter detent |
| 6. HP gauge shutoff valve | 21. Fill system relief valve (#2 system) | 36. Cylinder head temperature gauge |
| 7. Low-pressure gauge | 22. Fill pump switch | 37. Fluid level indicator |
| 8. Deleted for simplification | 23. Fill system duplex gauge | 38. Heater controls |
| 9. Low-pressure gauge selector valve | 24. Fill system relief valve (#1 system) | 39. Reservoir pressurization selector valve |
| 10. Sight tube | 25. Push-to-fill valve (#1 system) | 40. Stand reservoir pressure gauge |
| 11. Flow control valve | 26. Ammeter | 41. Stand reservoir pressure regulator |
| 12. Compensator control | 27. Hourmeter | 42. Aircraft air pressure shutoff valve |
| 13. HP filter warning light | 28. Engine oil temperature gauge | 43. Aircraft air pressure regulator |
| 14. Filter bleed valve | 29. Ignition switch | 44. Aircraft air pressure gauge |
| 15. Bypass through flowmeter | 30. Engine control power circuit breaker | |

Figure 5-6. Instrument and control panel (MJ-2A).

controls in the center. The identification of the controls on the system #1 panel have been deleted for clarity. These controls are duplicates of the controls for system #2. For this reason, we shall only discuss the operation of the #2 system.

The first step in setting up the control panel is to depress the engine control power circuit breaker (item 30 of figure 5-6). At this time power is applied to all control devices and circuits of the hydraulic test stand. The fluid level indicator (37) will now indicate the amount of fluid in the

reservoir. The reservoir should be serviced as required before operation. The panel lights behind the sight tube (10) and the system flowmeter (2) will light. Of course, the corresponding lights in system #1 will also light.

You are now ready to fill and bleed the system. The reservoir selector valve (19) must be placed in the EXTERNAL position. The flow control valve (11) must be fully closed. Set the low-pressure gauge selector (9) to the FILTER INLET position. Place the reservoir pressurization valve (39) in the

VENT position. The high-pressure gauge shutoff valve (6) should be fully closed, then opened one-quarter turn. Both the bypass through flowmeter valve (15) and the bypass through cooler panels are now set up to fill the lines and components of the #2 system.

Filling and bleeding. The filling and bleeding operation is begun by placing the fill pump switch (22) in the ON position. The pump motor will then operate, but no system pressure will be developed. To pressurize the system, you must depress the push-to-fill valve (20). At the same time you should turn the relief valve handle (21) clockwise until a pressure of 15 to 20 psi is indicated on the low-pressure gauge (7). You may have difficulty in obtaining the desired pressure. Don't give up. When the system contains a large volume of air, pressure will not immediately build up on the low-pressure gauge. In order to bleed the system, you must depress the filter bleed valve (14). You should observe the sight tube (10) as you bleed the system. The air in the system will collect in the low-pressure filter housing. When the bleed valve is depressed, you will notice bubbles in the fluid. You should continue to pressurize and bleed the system until a solid column of fluid can be seen in the sight tube. The fluid should be clear and bright red in color. The appearance of a pink, milky fluid indicates that there is air in the system.

If it has been determined that both systems are to be operated, you must also fill and bleed the other system. The procedures for filling system #1 are the same as those for system #2. The #1 control panel must be set up with all valves placed in the same positions as those on the #2 panel. When the filling and bleeding operation for one or both systems, as desired, is completed, place the fill pump switch (22) in its OFF position.

Starting the engine. Before the engine is started, you must engage the clutch for the system to be operated. This will engage the desired systems pump to the engine. (NOTE: Never change the position of the clutch handle while the engine is running.)

We will set up the control panel for operation without a connection to the aircraft. The bypass through cooler (17) valve should be fully closed at this time. The volume control (16) must be turned to its minimum flow position (fully counterclockwise). Both the compensator control (12) and the relief valve (18) must be set at their minimum ranges (fully counterclockwise). You should, however, be careful not to strip the threads on the compensator handle. Back the valve handle off to its stop, then turn it back clockwise just enough to free the handle from its stop. The unit is now set up for starting the engine.

The choke (33) should be pulled out and the ignition switch (29) must be turned on. Next, you must pull the throttle handle (34) all the way out

(idle), then push it back in about a quarter of an inch. To start the engine, move the starter switch (31) to its momentary ON position and hold it until the engine starts. When the engine starts, slowly push in the choke until the engine runs smoothly with the choke fully opened. Allow the engine to idle until the engine cylinder head temperature gauge (36) indicates in the green area. The engine oil pressure gauge (32) should indicate the presence of oil pressure in the engine. If no oil pressure is shown, stop the unit at once. Do not depend on the oil pressure switch to stop the unit.

While the engine is idling and warming up, depress the filter bleed valve (14) and observe the fluid flow. There should be no air bubbles. If bubbles are present, allow the unit to continue to idle until you have bled all air from the system. After the engine is warm, push in the throttle handle (34) to increase engine speed. At every 200-rpm change, depress the filter bleed valve (14) and check the air in the system. When the throttle is pushed completely in, the engine speed is automatically regulated by the governor. Engine speed should be governed at approximately 2550 rpm. After the engine is running at full rpm, you should check the operation of the boost pump by placing the low-pressure gauge selector (9) in the PUMP INLET position. A negative pressure should be indicated on the low-pressure gauge (7). You can check the low-pressure filters by checking filter inlet and filter outlet pressure. A pressure differential indicates that the filters are dirty. The maximum allowable difference can be found in the applicable TO for the unit.

Setting the relief valve. Previously, we set the high-pressure relief valve to its lowers pressure setting. At this time, we must decide the pressure and volume at which we desire to test the high-pressure system. Let's assume we need a flow of 20 gallons per minute at a pressure of 3000 psi.

While you are observing the flowmeter (item 2 of figure 5-6), turn the volume control (16) slowly clockwise until the edge of the flowmeter float aligns itself with the 20-gpm mark on the flowmeter scale. this adjusts high-pressure pump output to 20 gpm. Next, you must close both the bypass through flowmeters and bypass through cooler valves (15 and 17, respectively). The flowmeter will now drop to 0 gpm, and the entire pump output will pass through the relief valve.

The next step is to adjust the pressure compensator (12) to some point above 3000 psi. Since you do not obtain any pressure with the relief valve set at 0 psi, you cannot tell when you have reached that point. A good rule of thumb is to turn the handle of the compensator $3\frac{1}{2}$ to 4 full turns clockwise. After the compensator has been set, unlock the relief valve handle (18) and turn it slowly clockwise. At the same time, observe the

high-pressure gauge (4). The pressure should increase slowly while turning the relief valve. If the pressure reaches a certain point below 3300 psi, and will not increase further, you have found the setting of the pressure compensator. You will then have to rotate the compensator handle (12) clockwise a few more turns.

You should continue to rotate the relief valve until a pressure of 3300 psi is obtained. To check the relief valve operation, you will have to open the bypass through flowmeter valve (15) and rapidly close it. The high-pressure gauge (4) should show a decrease when the valve is cracked open. It should return to 3300 psi when the valve is closed. If the gauge does not return to 3300 psi, you will need to readjust the relief valve. This must be repeated until the relief valve maintains pressure at the desired setting. Once the relief valve has been properly adjusted, you should lock the handle into place by rotating the locking handle fully clockwise.

Setting the pressure compensator. After the relief valve has been set, you must adjust the pressure compensator (12). You will recall that the compensator was previously set at some point above the relief valve. All that is required at this point is to rotate the compensator counterclockwise while observing the high-pressure gauge. The pressure will drop to 3000 psi as the handle is rotated. When the desired pressure is obtained, the compensator handle must be locked into place in the same manner as the relief valve.

Pressurizing the reservoir. In many aircraft maintenance situations it will be necessary to pressurize the stand reservoir. This is accomplished by placing the reservoir pressurization valve (39) in the PRESSURIZE position. You must then adjust the air pressure by rotating the handle of the reservoir air pressure regulator (41) until the desired pressure is indicated on the air pressure gauge (40). For testing purposes, this pressure may be adjusted to 15 to 20 psi. The aircraft air pressure regulator (43) may also be tested while you observe the aircraft reservoir pressure gauge (44).

While operating the MJ-2A hydraulic test stand, the fluid temperature will increase. Observe the temperature gauge (1) during the testing operation. If the temperature approaches the red area on the indicator, open the bypass through cooler valve (17). This will allow the fluid to pass through the cooler. The unit must be allowed to continue to run until the temperature of the fluid decreases to a safe level (below the red line temperature).

Shutdown. The procedures used to shut down the hydraulic test stand are almost as important as the runup procedures. You must open the bypass through cooler valve (17), and the bypass through flowmeter valve (15). This relieves pressure on the system. The engine must be idled by pulling out the throttle handle (34). It should be allowed to cool for approximately 5 minutes at idle speed. After cooling, push in the throttle and place the ignition

switch (29) in the OFF position. Pull out the control circuit breaker (30). At this time, all panel lights will extinguish. Place the reservoir pressurization selector valve (39) in the VENT position. Before closing the access doors, open the air filter moisture drain valve located on the bottom of the air filter near the low-pressure filters. After the air pressure is drained off, close the valve. All doors must be closed and the battery. All doors must be closed and the battery disconnected, if required by local directives.

If the MJ-2A is operated in the prescribed manner following the applicable TO, you are reasonable certain that it will operate when used on the flight line.

Exercises (262):

1. What additional danger is associated with the hydraulic test stand?
2. How do the #1 and #2 system panels differ?
3. Where are the four control panel lights located?
4. In what position must the reservoir selector valve be placed prior to filling the system?
5. Explain why the compensator must be initially set at a point above 3300 psi before adjusting the relief valve to 3300 psi.
6. When you intend to operate a system, why must the clutch for that system be engaged?
7. When will the bypass through cooler valve be opened?
8. What should be done if no engine oil pressure is shown on the oil pressure gauge once the engine is started?

5-2. Air Compressors

Most of us know that the noisy jack hammers used for breaking concrete are actually air hammers operating off compressed air. We are also aware that commercial painting is often done with a compressed air paint sprayer, and that we get pressurized or compressed air from the gas station for our car tires.

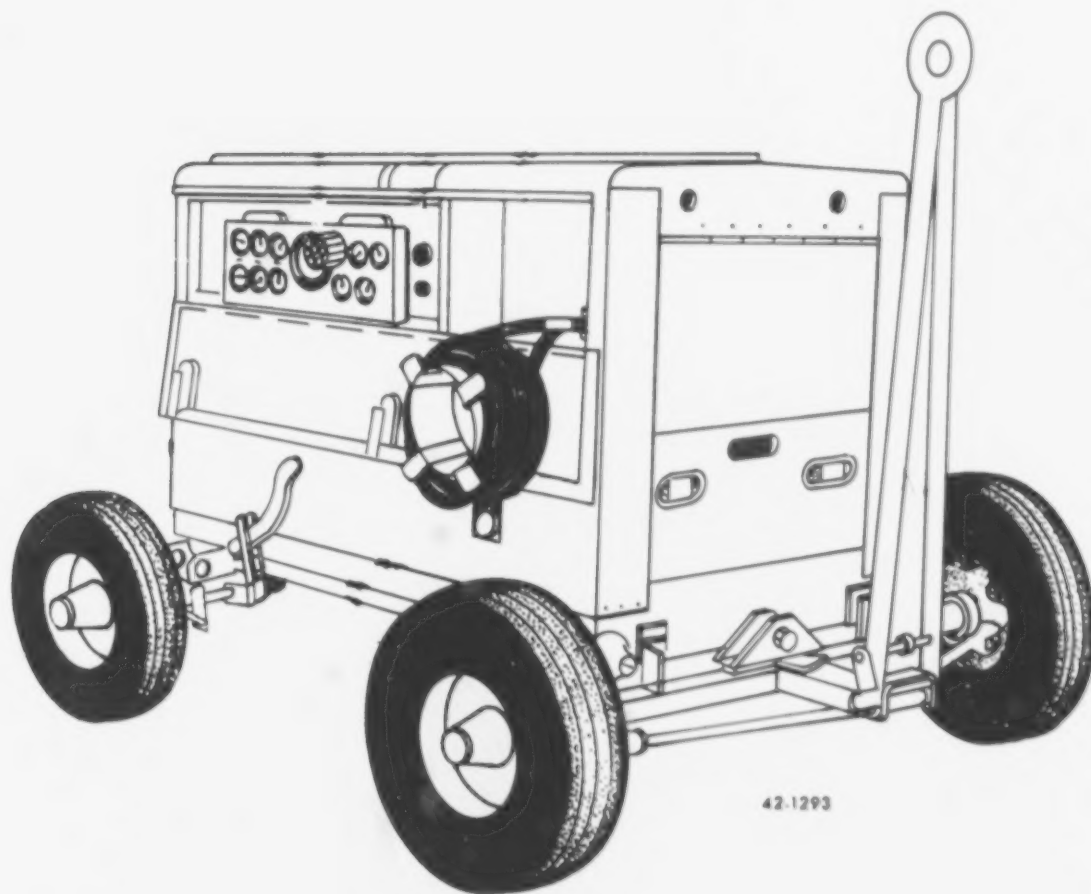
In today's modern Air Force, compressed air plays a major role in servicing our aircraft. Compressed air is used to start jet engines, to precharge hydraulic accumulators and landing gear struts, and to operate several systems in emergency.

Because part of our job consists of servicing and operating aircraft system that use compressed air, we should be able to operate the units that produce it. One of these units is the MC-1A air compressor. In section we will talk about the construction, operation, and schematic circuits on the MC-1A.

263. Specify the purpose of the reciprocating compressor accessory and control components.

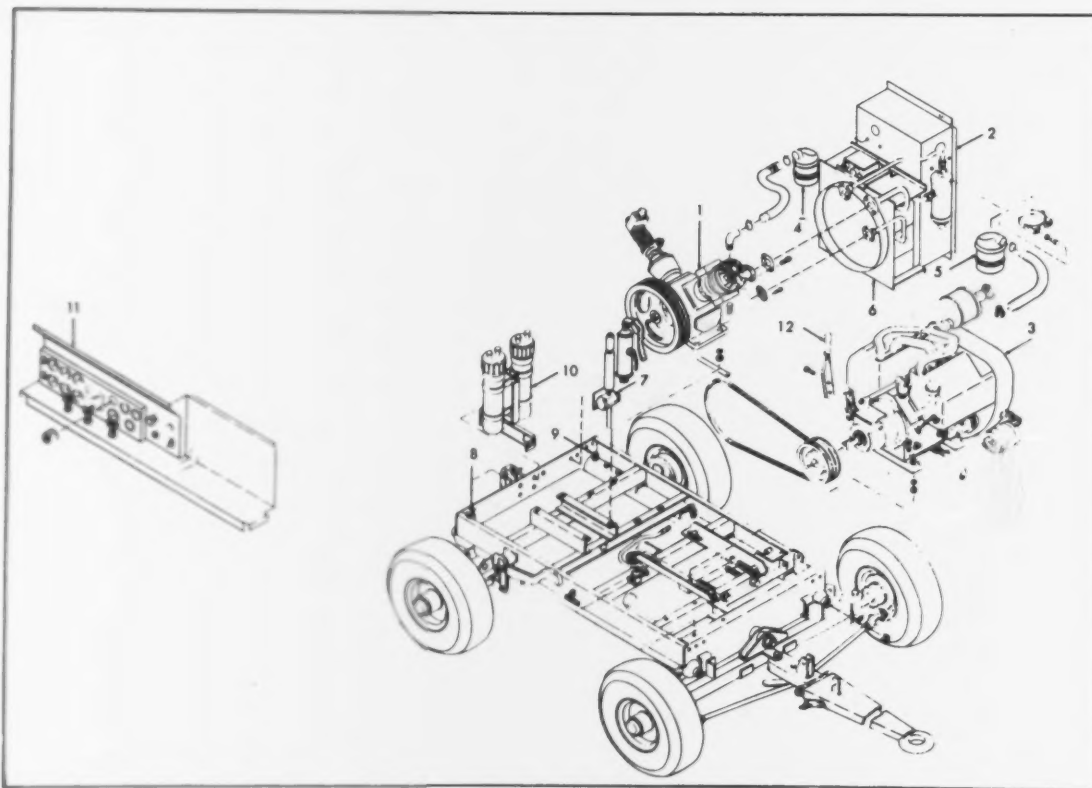
MC-1A Air Compressor. The MC-1A, figure 5-7, is an engine-driven reciprocating air compressor. It is capable of continuous operation at a capacity of about 15 cubic feet of free air per minute. It provides servicing pressures in the high range of 3500 pounds per square inch. It is used for supplying air for servicing aircraft pneumatic systems. The compressor is portable and transportable by aircraft and comes in many different models. In this section we shall cover some of the major components of the MC-1A.

Inlet air duct assembly. The compressor (figure 5-8, item 1), with its associated inlet air duct assembly (2), is a box-like sheet steel inclosure. the large opening permits air to circulate over the coils of the aftercooler and intercoolers. The inlet has two doors held open with a hook-type latch when the unit is in operation. Mounted in the recessed position of the assembly above the doors are the engine (3) and the compressor air cleaner (4). The engine air cleaner (5) is located forward, outside of the recess.



42-1293

Figure 5-7. MC-1A air compressor.



42-1146

- | | |
|--|----------------------------------|
| 1. Compressor | 7. Unloader valve assembly |
| 2. Inlet air duct assembly | 8. Pressure relief valve |
| 3. Gasoline engine | 9. Shear disk-type relief valve |
| 4. Compressor air cleaner | 10. Dehydrator assembly |
| 5. Engine air cleaner | 11. Instrument and service panel |
| 6. After cooler and intercooler assembly | 12. Clutch lever |

Figure 5-8. Exploded view of MC-1A air compressor.

Compressor air cleaner. The compressor air cleaner (figure 5-8, item 4) is an oil bath air cleaner located in the upper recessed opening of the inlet air duct assembly. The air cleaner is easily removed for cleaning. A flexible hose couples the air cleaner to the intake elbow of the first stage cylinder head.

Cooler group. The aftercooler assembly and intercoolers (figure 5-8), item 6) are constructed of finned tubing suitable for handling the pressure encountered. Each intercooler is a separate section of coil tubing nestled within a bracket. The three brackets are stacked, with the larger tubed first stage at the top, and the smaller tubed third stage at the bottom. The aftercooler for the fourth stage is arranged over the face of the stacked assembly. Cooling is accomplished by having the finned cooling tube located in the inlet airstream of the fan.

The intercoolers and the aftercooler remove the heat caused by compression from the air as it moves from one stage to the next. The cooled compressed air causes condensation, which is removed from the air at the individual cooler separators.

The intercoolers and aftercooler are provided with individual separators. Moisture-laden air enters each separator. Since the air is lighter than the moisture, air rises to the top of the separator and is driven to the next stage of compression. The moisture and oil settle to the bottom of the separator and are piped to the check valves in the unloader valve assembly.

Unloader valve assembly. The unloader valve assembly (figure 5-8), item 7) is a hexagonal block located on the left-hand side of the unit. The unloader supports the check valves for the first,

second, third, and fourth stage separator. A three-way, normally closed (electrically energized), solenoid valve admits the second stage discharge air pressure to the unloader valve assembly. The electrical circuit to the solenoid is hooked in series. If the compressor oil pressure decreases below 15 psig, if the air pressure exceeds the pressure switch setting of 3500 psig, or if the manual drain switch is positioned to UNLOAD, the circuit will be broken. With the electrical circuit broken, the unloader releases the second stage discharge air pressure. This pressure allows the piston inside to move off its seat, thus, releasing moisture from the separators.

An individual stage check valve is mounted on the unloader body. It prevents higher pressure air (within the unloader) from returning to lower pressure compression stages. The first and second stage valves serve only as check valves. The third stage valve is both a check and a back-pressure valve. It maintains a minimum third stage cylinder pressure when the compressor operates unloaded. The fourth stage valve serves only as an unloaded operations back-pressure valve.

Pressure relief valves. Each stage of compression has a spring-loaded pressure relief valve designed to operate at a pressure that will protect the compressor. The operating point of the pressure relief valve is set high enough to allow for momentary surges that occur as a cylinder discharges. The final discharge pressure relief valve is located on top of the right-hand air receiver (8). It is spring-loaded, set at 3800 pounds. A shear disk relief valve (figure 5-8, item 9) is located on the left-hand air receiver. This protects the compressor against a sudden rise in pressure which the fourth stage pressure relief valve could not handle.

Dehydrator assembly. The dehydrator assembly (figure 5-8, item 10) consists of two purifier cylinders. Both cylinders are mounted in a vertical position on a common bracket. A nameplate on the bracket identifies the cylinders as holders 1 and 2. A dehydrator instruction plate, fastened to the outside of the toolbox, gives instructions for changing the cartridges. A space is provided on the plate for recording the hours at which the cartridges were last changed.

The dehydrators absorb moisture in the compressed air which was not removed in the compressor separators. Each cylinder is equipped with two cartridge perforators, one at the top and one at the bottom. A spring-loaded seal ring with two O-rings creates a positive seal between the cylinders and cartridge. The spring also allows for variations in cartridge length. The dehydrator cylinders are connected in series, so that air leaving the fourth stage separator enters the bottom of the first dehydrator cylinder and leaves from the side. From there, the air is piped to the bottom of the second cylinder, leaves from the side, and is piped to the 10-micron filter. (The series F dehydrators

receive air from the air receivers instead of the fourth stage separator.)

10-Micron air filter. The 10-micron air filter, part of the service panel (figure 5-8, item 11) is a cylindrical casting. It contains a replaceable element which is easily removed. The filter which is readily accessible at the rear end of the compressor, removes particles from the air down to 10-microns in size and passes the air on to the priority valve.

Priority valve. The priority valve is mounted on the 10-micron air filter after the dehydrator. It is a pressure-actuated device that insures maximum effectiveness of the dehydrator. It prevents air from passing through the dehydrators at low pressures. The priority valve remains closed until the pressure in the supply line from the compressor reaches 2400 psi. The valve will open, maintaining supply line pressure at 2400 psi until downstream pressure exceeds 2400 psig.

Instrument and service panel. The instrument and service panel (figure 5-8, item 11) contains the necessary indicators and controls for the operation of the air compressor unit. Two panel lights illuminate the various gauges and controls.

The pressure gauges indicate the air pressure of each compression stage, pressure in the air receivers, servicing hoses, compressor oil and engine oil pressure.

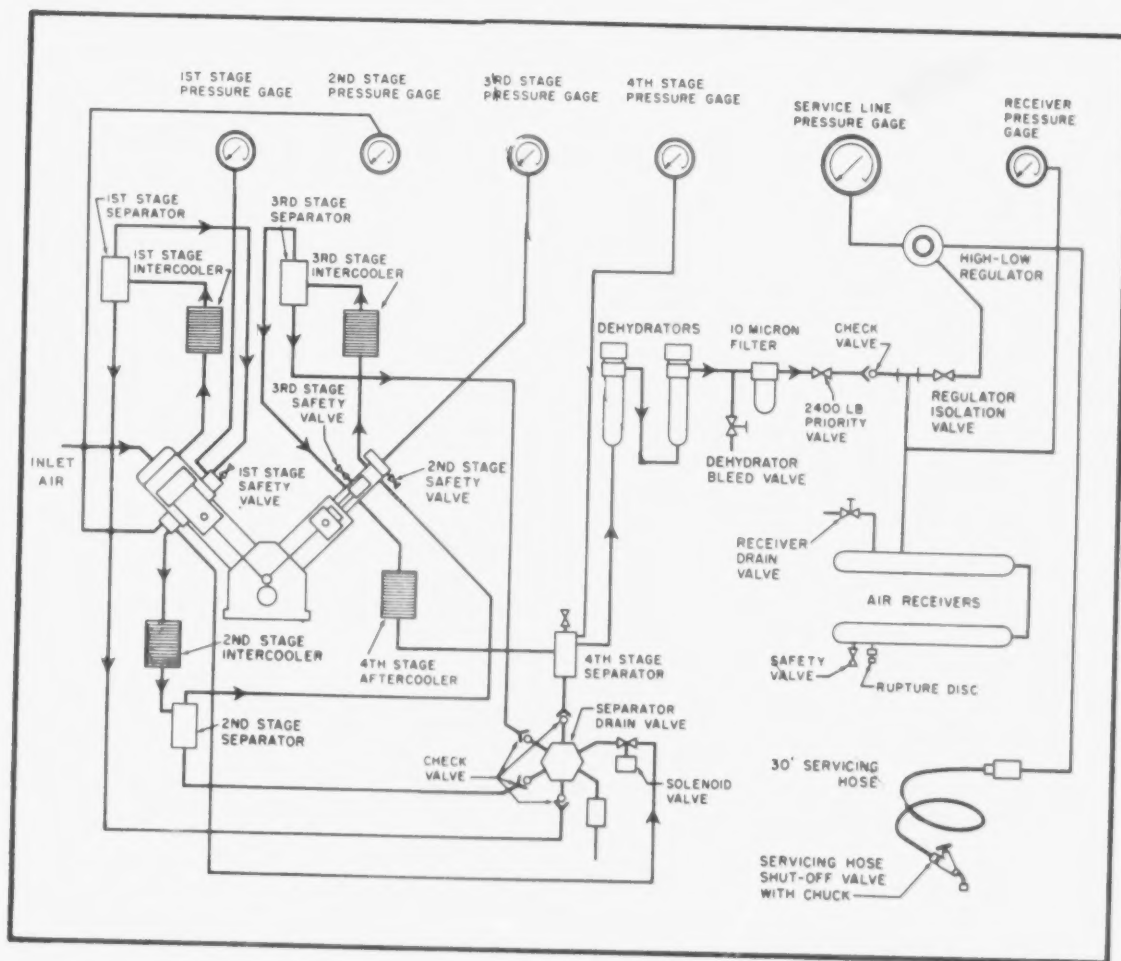
Exercises (263):

1. Describe the type of air cleaner used on the reciprocating compressor.
2. Describe the purpose of the intercoolers and aftercooler.
3. What is the purpose of a separator?
4. Separators are piped to check valves in what component?
5. List three conditions which cause the unloader valve to unload.
6. Why must each stage have a pressure relief valve?

7. What is the purpose of the dehydrator assembly?
8. Air that leaves the dehydrator assembly is piped to what component?
9. What is the purpose of the priority valve?

264. Using an airflow diagram, match the function to the key component airflow systems.

First Stage Sequence. Air enters the inlet or suction side of the first stage cyclinder (figure 5-9). It is compressed in the first stage cylinder to approximately 50 psi. As you may recall, air being pressurized becomes quite hot. Therefore, the pressurized air leaving the discharge side of the first stage flows through the first stage intercooler. The cooling process causes moisture condensation to form in the intercooler. It then flows into the first stage separator. From the separator, this oil and air condensate is piped to the separator check valve at the unloader (separator drain valve). This check valve prevents high-pressured air within the unloader from entering lower pressured stages during compressor unloading. The lighter dry air is piped to the second stage suction valve. Notice that the first stage pressure gauge is tube-connected on



42-1143

Figure 5-9. Airflow schematic (MC-1A).

the suction side of the second stage cylinder. Also, excess first stage pressure, if any, is relieved by the relief (safety) valve at this point.

Second Stage Sequence. Air enters the second stage where it is compressed to approximately 290 psi. Exhausted from the second stage, it goes through the second stage intercooler, and moisture-laden air from the separator is piped to the separator check valve at the unloader valve. On this stage of compression, the pressure gauge is attached to the second stage discharge housing. The second stage safety valve is located on the inlet side of the third stage cylinder. Notice the additional air line leaving the second stage cylinder and going to the solenoid valve (next to the separator drain valve). This second stage air control line normally keeps the unloader valve closed. However, if the solenoid drain valve is deenergized for any reason, second stage air is shut off, and the drain valve releases compressor air.

Third Stage Sequence. Dry air from the second stage separator is piped to the third stage cylinder. It is compressed to about 900 psi and is exhausted to the third stage cooler and separator for conditioning. The third stage pressure gauge line is connected to the third stage head. The third stage safety valve is connected to the exhaust side of the third stage cylinder.

Fourth Stage Sequence. The main airflow now enters the fourth stage, where it is further compressed until the pressure builds up to 2400 psi. Since this is the last stage for cooling the compressor air, we identify the cooler as an aftercooler. The air then passes through the fourth stage separator to the separator drain valve, and dehydrators.

External Airflow Components. Pressurized air passes through the dehydrators and is cleaned of partially all condensate. It then passes through the 10-micron filter that removes particles from the air as small as 10 microns in size. The air then approaches the 2400-psi priority valve. Until the air discharged from the fourth stage to the priority valve reaches 2400, it travels no further. As we have stated previously, this pressure causes the dehydrators to operate more effectively. The dehydrator bleed valve can be opened to remove any moisture in the dehydrators. Once the pressure reaches the priority valve setting, it passes through the one-way check valve to the receivers or to the regulator isolator valve. The pressure will continue to build up until it reaches 3500 psi. The pressure switch then will automatically unload the compressor.

The air is stored in the receivers until it is needed. The receiver pressure gage indicates the pressure in the receivers. The receiver drain is used to drain any condensation from the tanks. When the regulator isolation valve is opened it allows the stored air to flow to the high-low regulator. By turning the regulator clockwise or counterclockwise,

it regulates the amount of air that goes to the servicing hose and air chuck.

Exercise (264):

1. Match the items in column A with the most appropriate definition in column B by writing the correct numeral in the blank space provided.

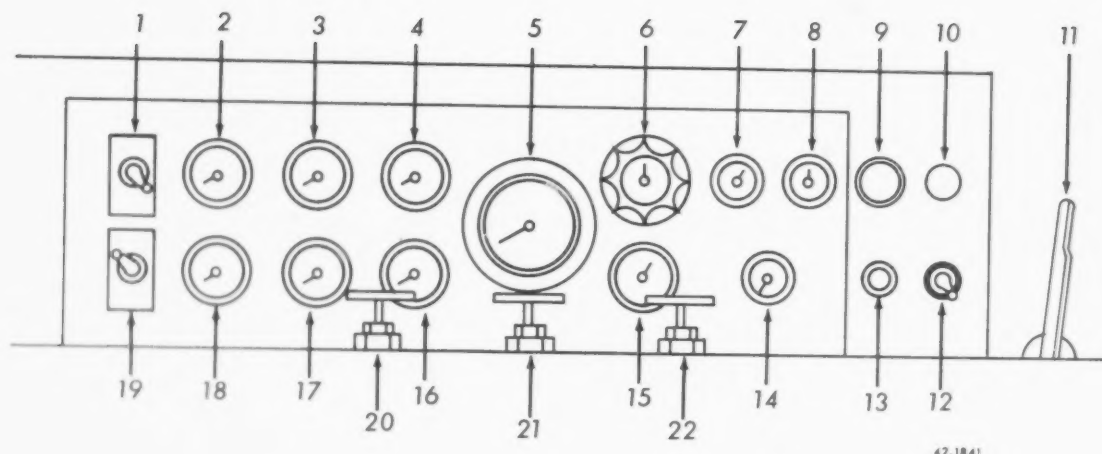
Column A	Column B
— a. Protects the stages and compressor from overpressurization.	(1) Separator.
— b. Maintains a back pressure to increase the effectiveness of the dehydrators.	(2) Intercooler.
— c. Dries the condensate from the compressed air.	(3) Separator drain valve.
— d. Used to drain condensate from the separators.	(4) Dehydrators.
— e. Cools the compressed air between stages.	(5) Priority valve.
— f. Accumulate oil and condensate.	(6) Safety valve.
— g. Opens at 2400 psi.	

265. Given a list of starting and operating procedures, arrange them in the proper sequence of operation.

Operating Procedures. With a service inspection completed on the MC-1A air compressor, the unit is now ready for operation and checkout. Use figure 5-10 as we discuss the MC-1A operation. Before we begin our starting procedures, let's cover a few safety precautions when operating the air compressor.

- (1) To prevent asphyxiation when you operate the engine in an inclosed area, always vent the exhaust gases to the outside atmosphere.
- (2) Tighten hand-operated valves only tight enough to prevent leakage. Overtightening damages the valve stems and seats.
- (3) Before making any repairs on components of the airflow system, relieve the system of all air pressure.

Starting. After satisfying the inspection and servicing requirements, make sure that the cover assemblies are raised and secured. Also make sure that the vent doors for the engine and aftercooler assembly are opened and secured. Turn the panel lights on by placing the panel light switch (1) to the ON position. Check the clutch handle (11) and make sure it is disengaged. To disengage the clutch, push the handle toward the instrument panel. Now you are ready to set up the engine controls. Make sure that the throttle control (9) is unlocked and pushed in to prevent the engine from overspeeding when it is started. It may be necessary for you to use the choke control (10) if climatic conditions warrant its use. The ignition switch (12) is now



- | | |
|------------------------------|-----------------------------------|
| 1. Panel light switch | 12. Engine ignition switch |
| 2. 1st stage pressure gauge | 13. Engine start button |
| 3. 2nd stage pressure gauge | 14. Fuel level gauge |
| 4. 3rd stage pressure gauge | 15. Receiver pressure gauge |
| 5. Service pressure gauge | 16. Compressor oil pressure gauge |
| 6. Hi-low regulator | 17. Hourmeter |
| 7. Engine oil pressure gauge | 18. 4th stage pressure gauge |
| 8. Engine ammeter | 19. Unloader drain valve switch |
| 9. Engine throttle | 20. Dehydrator bleed valve |
| 10. Engine choke | 21. Regulator isolation valve |
| 11. Clutch lever | 22. Receiver drain valve |

Figure 5-10. Instrument and service panel (MC-1A).

placed in the ON position to start the engine. Crank the engine over by pressing the starter button (13). As soon as the engine starts, release the starter button and push the choke control in slowly. Regulate the choke control to allow the engine to idle smoothly as the engine warms up. As you regulate the choke control, observe the engine oil pressure gauge (7) for an indication of pressure. If the engine oil pressure doesn't register, turn the ignition switch off to shut down the engine. Determine the cause for no oil pressure and correct the trouble. When normal pressure is indicated, allow the engine to warm up before engaging the clutch.

The hourmeter (17) records hours when the compressor operates loaded—that is, compressing air. The engine ammeter (8) indicates generator performance. The fuel level indicator (14) indicates the level of fuel in the tank.

Charging receivers. While the engine is warming up, check the instruction placard for the proper position of the control valves. Make sure that the receiver drain valve (22) is closed and dehydrator bleed valve (20) is closed as pressure will not build up with these valves open. With all valves positioned as specified on the instruction placard, pull the throttle control halfway out and lock it. This will prevent the engine from stalling when the

clutch is engaged, and when a load is placed on the engine. The clutch lever is pulled toward you as you engage it. When the clutch is engaged, it will be necessary to pull the throttle control out to governed speed. Turn the throttle control to unlock it, and pull it out until it stops, then lock it again. The engine governor will now control engine speed.

The compressor will now build up pressure that will be indicated on the various stages of compression on gauges 2, 3, 4, and 18. Observe the compressor oil pressure gauge for a reading of pressure (16). Check the instruction placard for the correct compressor oil pressure. If the correct pressure is not indicated on the gauge, disengage the clutch and determine the cause for insufficient compressor oil pressure. Remember, the receiver pressure gauge will not indicate pressure until the maximum pressure (2400) can pass through the priority valve to the receiver. So, check this gauge after the receiver is fully charged. Compare the gauge reading with the normal readings listed on the instruction placard or in the technical order. If normal pressures are indicated for all stages and the receiver, you may now check out the service hose pressure regulators. This will depend upon the type of compressor on which you are working. Check out the regulation of both the low-pressure system and the high-pressure system. You may have only

one regulator (6) for both systems. To allow pressure to reach the regulator, the isolation valve (21) must be opened. After the regulators have been checked out and found to be functioning properly, you may shut down the unit.

Stopping. To shut down and the compressor, disengage the compressor clutch by pushing the clutch handle toward the instrument panel. Then unlock the throttle control and push it in slowly to reduce engine speed to an idle. This will allow the engine to cool down while it idles. The receiver drain valve (22) must be opened to relieve the pressure in the receiver. Also, check the instruction placard for any other valves that should be opened to relieve pressure. When the engine has cooled sufficiently, turn the ignition switch to the OFF position to shut down the engine. The unload drain valve will automatically unload the separator of moisture once the engine shuts down. Another way of unloading the separator of moisture is by manually placing the unloader drain valve (19) to the unload position. The service hose or hoses can now be stored in their compartments. All cover assemblies are now closed and latched to secure the unit for the ready-line.

Exercise (265):

1. Arrange the following starting and operating procedures in the logical sequence of operation by numbering them 1 through 8 in the space provided.
 - ___ a. Engage the clutch.
 - ___ b. Turn on the load switch.
 - ___ c. Use the choke.
 - ___ d. Turn on the ignition switch.
 - ___ e. Check the pressure gauges.
 - ___ f. Open the panel covers.
 - ___ g. Unlock the throttle and push it in.
 - ___ h. Check the regulators.

5-3. Generator Sets

There are many types of powered aerospace ground equipment. The units described in this section are representative of those you may come in contact with as a pneumatic mechanic. Operating procedures and safety are of the utmost importance during the operation of this powered equipment. Some of the more common ones were highlighted in the previous sections. In this section we will acquaint you with some of the specific safety practices that you should observe while operating the MD-3 and the A/M 32A-60 generator sets.

266. State the purpose and the voltage outputs of the MD-3 generator set, including the split bus system, and specify the number of generators and the cable that deliver alternating current to the aircraft.

MD-3 Generator Set. The MD-3 generator set supplies electrical power for starting aircraft engines, and for making operational checks of electrical system units without the engine running. The use of this generator set saves the aircraft engines and electrical supply system from prolonged use on the ground for checking operation of electrical system units. Its use reduces maintenance on aircraft electrical systems and adds to their reliability.

The MD-3 is slowly being replaced by the more efficient and reliable A/M32A-60. Over the years, the basic MD-3 unit has been modified removing generators, cords, etc., and redesignating them as MD-3A and MD-3M. We will confine our discussion to the original MD-3 since similar equipment is found on the modified unit.

The MD-3 generator set, shown in figure 5-11, is designed to furnish 28-volt DC and 115-200-volt, three-phase, 400-Hz AC electrical power for ground operation and calibration of aircraft systems and instruments. It can also supply the electrical power required to operate relays, ignition systems, etc., during aircraft engine starts. Three 28-volt, 500-ampere DC generators and one 115/200-volt, 400-Hz, three-phase alternator produce the electrical energy for the MD-3. The generators and the alternator are driven by a gasoline engine. This unit is mounted on a three-point suspension dolly. It is equipped with the following:

- An electrical control box.
- An instrument panel.
- Power distribution compartments.
- A heating system.
- A cooling system.
- A three-speed, self-propelling, front-wheel-drive unit.

The unit provides the necessary electrical current for aircraft using either the single-bus or split-bus DC electrical systems as well as a single- and three-phase AC system.

The single-bus system consists of the three 500-ampere DC generators connected in parallel. The three generators combine their output to the two oval plug cables, shown in figure 5-12, for singlebus operation. The cables are located in the cable storage compartment. The alternating current is provided by the 60-KVA, three-phase, four-wire, 115/200-volt, 400-Hz alternator. The current flows from the set to the aircraft through the square plug cable. Single phase (115 volts) or three phase (115/200 volts) can be selected by placing the AC control selector switch in the desired position.

When using the split-bus system, the current from one generator flows through the one or two oval plugs for operation of the aircraft instruments and accessories. The other two generators supply current through the rectangular plug for electrical power used during aircraft engine starting. This

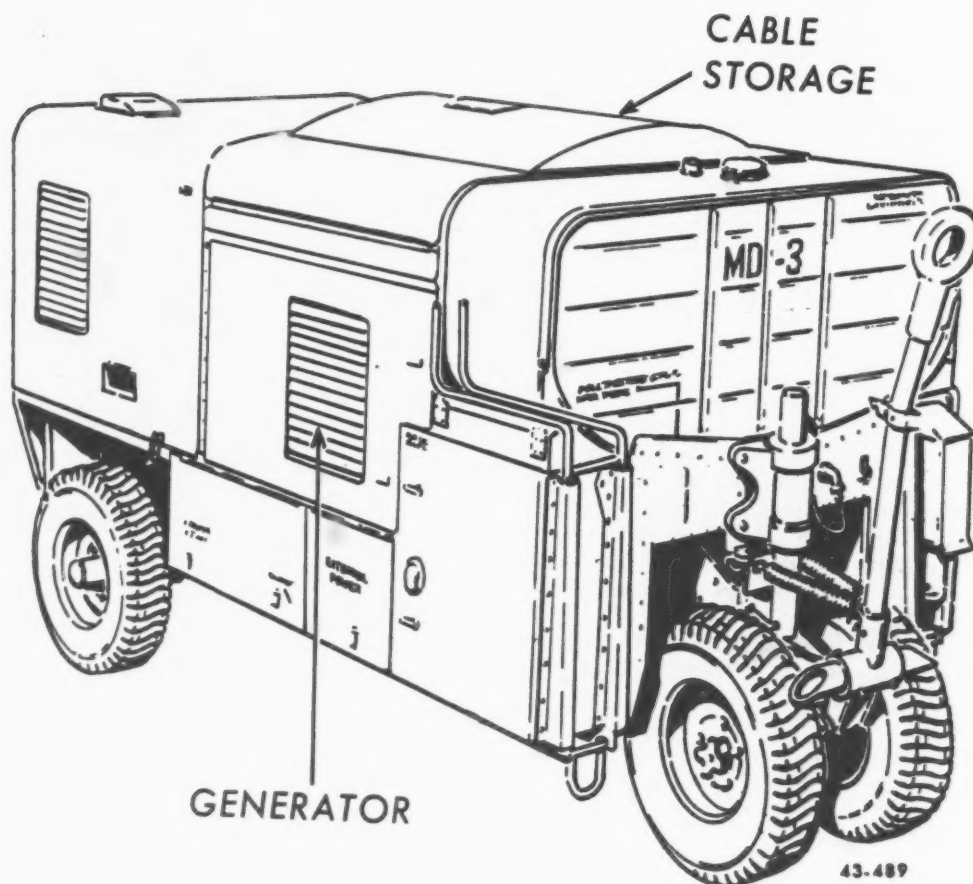


Figure 5-11. MD-3 generator set.

rectangular plug also shown in figure 5-12 receives a 19- to 28-volt signal from the aircraft when the engine starting system engages. This signal is then transmitted to the generator set and automatically splits the generator set bus. Therefore, the primary purpose of the split-bus system is to provide adequate power for electrical engine starting. At the same time this system also furnishes 28 volts for operation of the aircraft instruments and electrical equipment.

Exercises (266):

1. What is the purpose of the MD-3 generator set?
2. What voltage outputs are available from the MD-3 generator set?

3. How many generators are there on the MD-3, and what are their voltage output?
4. Through what cable is alternating current delivered?
5. What is the primary purpose of the split-bus system?

267. State the precautions and operating conditions relating to the MD-3 (in terms of starting procedures, applying a load, and the front-wheel-drive mechanism), and given a list of systems and operations, match the system or operation to the condition.

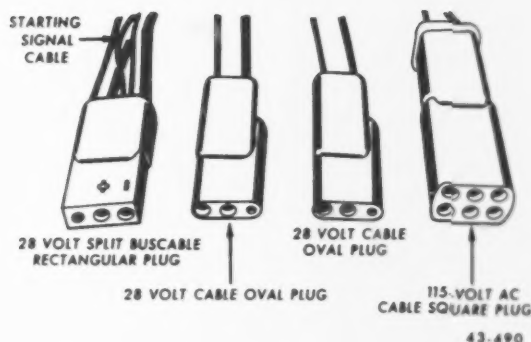


Figure 5-12. Generator cables.

MD-3 Operation. We break down the operating procedures as follows: engine starting and warmup, electrical system operation, and front-wheel-drive operation. You must be thoroughly familiar with the function of each control before you attempt to operate the unit.

Engine starting and warmup. Before you attempt to start the engine, always check the fuel and oil quantities. Check the engine crankcase for the proper oil level. Check the fire-extinguisher seal and the battery water level. The front-drive switch must be in the OFF position. Open the control panel and make sure that all ON switches are off and that circuit breakers are reset. (See figure 5-13).

The engine is started by first turning the ignition and battery switch (12) to ON. The cooling system warning light (14) and the AC power light should be on. Pull the throttle about $\frac{1}{4}$ open, and choke are required, depending on the ambient temperature. The choke must be used sparingly because the engine is easily flooded. Hold the starter switch on until the engine starts. If the engine fails to start in a reasonable length of time, push the choke in, turn the ignition and battery switch to OFF, and clear the engine by holding the starter switch in for 5 to 10 seconds. After the engine starts, warm it up at 800 to 900 rpm until it is running smoothly. Turn the ignition and battery switch to OFF momentarily and then back to ON to check the switch for operation. If the engine stops firing with the switch in the OFF position, the switch is operating properly. If the oil pressure (11) does not come up within 30 seconds after the engine starts, stop the engine and determine the cause. Oil pressure should read 20 to 40 psi at IDLE. Cylinder head temperature and the oil temperature gauge (9) should indicate a rise in temperature.

After warmup, push the throttle all the way in. The tachometer (10) should indicate 2250 rpm, and oil pressure should indicate 40 to 60 psi. If the tachometer does not indicate 2250 rpm, the ground power maintenance people must adjust the

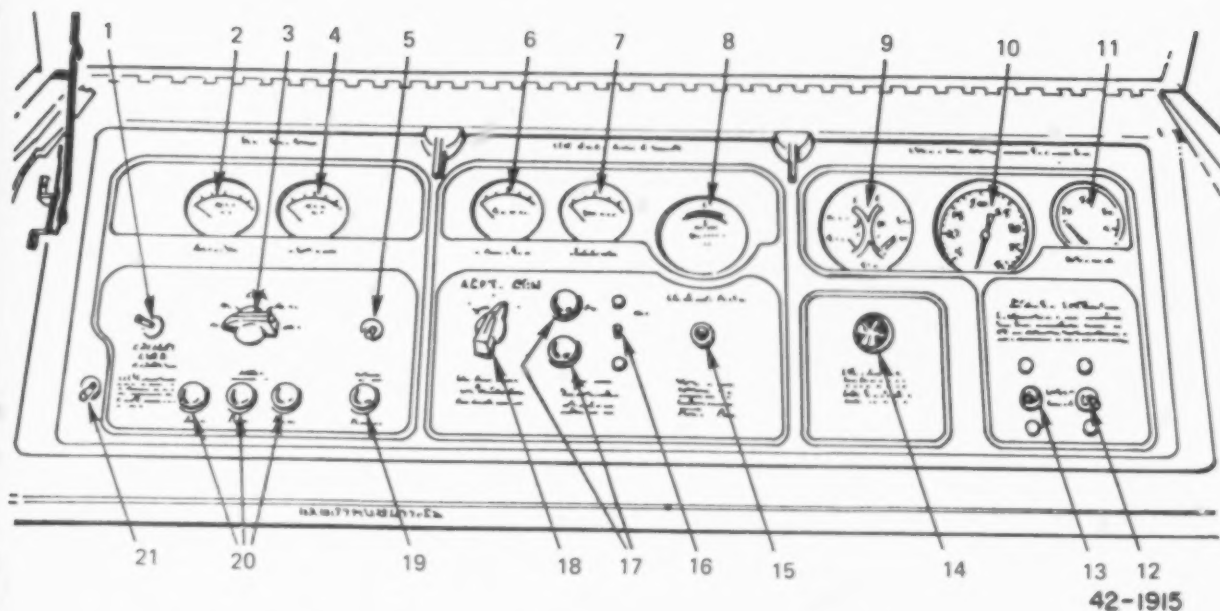
governor. Apply the load if the rpm is correct and cylinder head and oil temperature indicators are in the green range. The cooling fan indicator light must be off for safe operation of the generators.

If the batteries are too low to start the engine, you may use external power. In this case, make sure that all switches are off. Then plug in the external power and turn the external power switch to the ON position. Turn the ignition and battery switch to ON and hold the starter switch on. After the engine is started, turn the external power switch to OFF and remove the cable. Turn on the DC generators for battery charging and cooling blower operation.

Electrical system. When you service aircraft with a single-bus electrical system, connect the oval plug cables to the aircraft. With the engine operating at a governed rpm, position in the DC power switch (5) to ON. Check the voltmeter (4) and ammeter (2) readings of each generator by using the meter selector switch (3). Each generator should show 28 volts, and the total amperage of the three generators should be 100 amps. Turn the DC power switch to OFF. Set the current-limit control switch (1) for the necessary amperage (1200 or 1800). Make sure that no part of the generator set touches the aircraft. Plug the oval plug cable or cables into the receptacles on the aircraft. Turn the DC power switches to ON. The green light for each generator (20) should come on. If the lights do not come on, press the reset button. Check the amperage output of each of the three generators. The readings of each generator should not vary more than 20 amps from the suggested output. The total amperage delivered to the aircraft will be 100 amps less than the total reading of the three generators, since the cooling fan motor draws 100 amps.

When you service the aircraft with the split-bus system, use the cable with the rectangular plug and the two cables with the oval plugs. The cable with the six-pin square plug is connected to the aircraft to supply 115/200-volt AC power. The paralleling switch must be in the No. 1 position to obtain full voltage.

After the engine is warmed up, set and lock the throttle to FULL OPEN. Turn on the DC generators and hold AC power switch (16) in the RESET position until the AC voltmeter (6) stabilizes at 115 volts. Release the AC power switch, push the frequency test button (15) and check the frequency indicator (8). The indicator should read 400, plus, or minus 1 cycle. Select single- or three-phase operation with the AC selector switch (18). Some later models of the MD-3 have the frequency meter removed, and the frequency must be taken from the aircraft meter. Turn the AC power switch to the ON position. To shut down the MD-3, turn all generator switches to OFF and let the engine run at a governed speed. Pull the throttle all the way out and hold it until the engine stops. Turn the ignition and battery



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- | | |
|---|--|
| 1. Current limit control | 12. Ignition switch |
| 2. DC ammeter | 13. Battery power circuit breaker |
| 3. DC meter selector switch | 14. Cooling fan indicator light |
| 4. DC voltmeter | 15. Frequency indicator test switch |
| 5. DC power ON-OFF switch | 16. AC power control switch |
| 6. AC voltmeter | 17. AC power indicator light |
| 7. AC ammeter | 18. AC control selector switch |
| 8. Frequency indicator | 19. DC power overvoltage indicator light |
| 9. Cylinder head and oil temperature gage | 20. DC generator indicator lights |
| 10. Engine recording tachometer | 21. Panel lights switch |
| 11. Engine oil pressure gage | |

Figure 5-13. MD-3 control panel.

switch to OFF and disconnect the power cable. Then turn all switches to the OFF position.

Front-wheel drive. After the engine has been started and warmed up, open and lock the throttle. Turn the DC generators on to charge the batteries. Place the knob in the right-front-wheel hub in to engage the drive mechanism. Put the front-drive safety switch in the ON position. Hold the towbar switch to the appropriate FORWARD or REVERSE POSITION and energize the drive motor by moving the towbar from the UP position toward the HORIZONTAL position. The low-speed control switch at the base of the towbar engages first as the towbar is lowered. As the towbar moves further toward HORIZONTAL, it next engages the medium-speed control switch and then the high-speed control switch. Do not exceed 5 mph with the drive mechanism engaged. If the unit is to be towed, turn the front-drive mechanism by pulling out the knob and turning it one quarter turn. Do not tow faster than 20 mph. When the clutch is disengaged and the towbar is in the UP position, you force the towbar crossarm against the tires to serve as a parking brake. The unit is steered by right or left movement of the towbar.

Exercises (267):

1. When starting the MD-3, why should care be taken when using the choke?
2. What precaution should the operator take before applying a load to the MD-3?
3. How is the front-wheel drive mechanically engaged on the MD-3?
4. How fast should the MD-3 be moved with the drive mechanism engaged and disengaged?
5. Match the system or operation in column B with the condition in column A. Column B entries may be used more than once or not at all.

Column A

- a. 2250 rpm.
- b. Oil pressure within 30 seconds.
- c. 1200 to 1800 amps.
- d. 28 volts, 500 amps.
- e. Low-speed control switch.
- f. 115/200 volts, 400 cps.

Column B

- (1) Engine starting.
- (2) DC electrical system.
- (3) Front-wheel drive.
- (4) Load rpm.
- (5) Warmup speed.
- (6) AC electrical system.
- (7) Idle speed.

- g. Safety switch.
- h. Oil pressure of 30 to 40 psi.
- i. 800-900 rpm.
- j. Six-pin square plug.

268. Specify hazards associated with the operation of the A/M32A-60 generator set and correct operating procedures and practices.

A/M32A-60 Safety Requirements. Figure 5-14 shows an external view of the A/M32A-60. Since this generator set is driven by a gas turbine engine, it combines the hazards of a gas turbine engine with those of a generator set.

The gas turbine engine turns approximately 10 times faster than an automobile engine. Care must be taken to prevent foreign objects (such as nuts and bolts) from being drawn into the inlet and through the engine. If foreign matter is ingested, the unit will be damaged and people may be injured.

Painted on the sides of the inclosure are two red lines to indicate the plane of rotation. It must be kept clear when the unit is operating. If a wheel should disintegrate, the pieces can be thrown a long distance. Standing directly in line with a turbine wheel is extremely hazardous and should be avoided whenever possible.

An especially predominant safety threat around gas turbine engines is the extremely high noise levels. If exposed to the noise for long periods of time (or frequently) without proper ear protection, an individual will suffer an immediate short term loss of hearing and possibly a permanent loss. Indications of overexposure to excessive noise are nervousness and emotional upset. The best protection from a possible loss of hearing is afforded by wearing both ear plugs and ear muffs.

The exhaust stream from the engine is hot up to approximately 10 feet above the exhaust stack. The high temperature and the velocity of the exhaust gases can cause serious damage or injury. This exhaust area must be avoided during and after operation. Also, the unit should be operated only in a well-ventilated area.

The bleed air hose presents another potential danger. If the hose is not properly secured, it may whip around and cause extensive damage to the equipment or injury to individuals. When storing this hose, make sure that it doesn't come in contact with the exhaust stack. It could be burned and left unserviceable.

The voltages produced by generator sets in AGE are quite sufficient to cause serious injury to people. Severe electrical shock may even result in death. Contrary to common belief, small currents through the body can be ill. The amount of current that passes through the body is determined by the circuit voltage and the body resistance. The

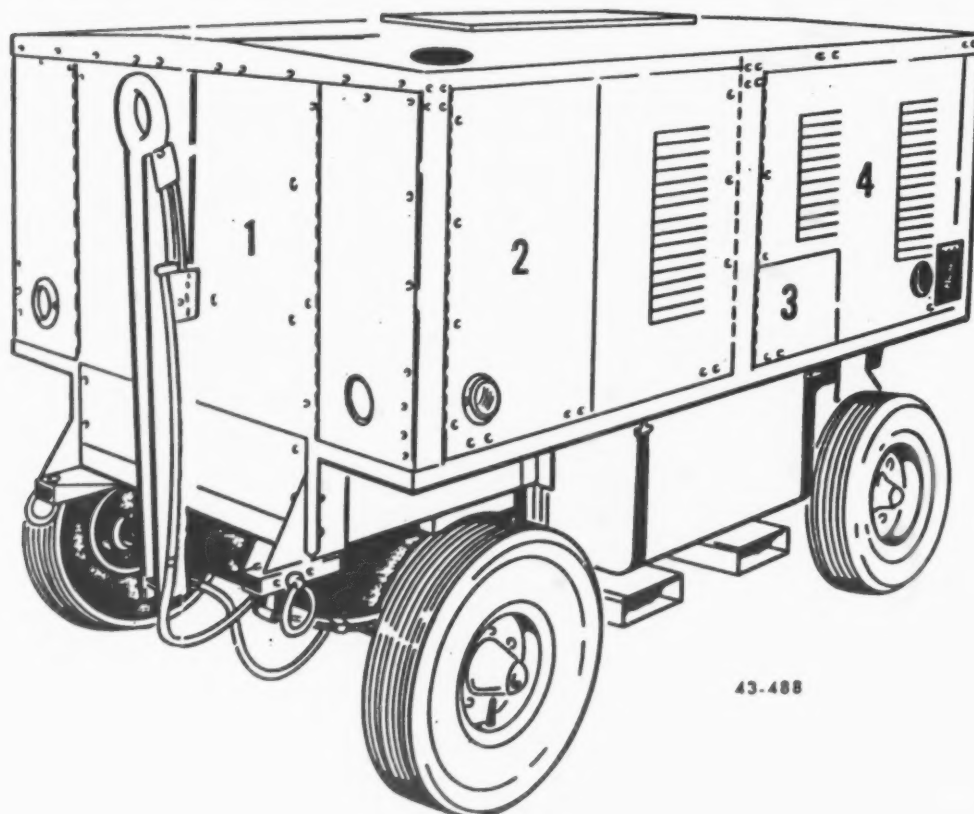


Figure 5-14. A/M32A-60 generator set.

voltages generated by this unit are far in excess of the amount required to cause serious injury or kill.

A/M32A-60 Operation. Foldout 1 is an illustration of the three instrument panels on the A/M32A-60 generator set. (Foldouts #1 and 2 are printed and bound in the back of this volume.) They are, from left to right, the AC, DC, and turbine instrument panels. You should refer to this foldout as we discuss the starting, loading, and shutdown procedures.

Starting. Push in the control circuit breaker (G) prior to starting. If you are operating this unit at night, place the panel lights switch (C) to the ON position, and panel lights (A, F, and K) will light the instrument panels. During every start of the unit, you must observe the exhaust temperature (X) and turbine speed (B) indicators. If the exhaust temperature exceeds 1300 F, you must immediately place the master switch (U) to OFF. If the unit fails to stop by placing the master switch OFF, close the fuel shutoff valve on the boost pump. Observe the turbine speed indicator to insure that the proper actions occur at the correct speeds.

Place the master switch in the ON position. This action starts the boost pump motor operating. Depress the lenses on all four indicator lights (M, R, T, and W) to insure that the bulbs are operational. If all bulbs are good, and the boost pump is operating, momentarily place the turbine start switch (V) to the ON position and then release it. The unit will accelerate to 10 to 15 percent, at which time combustion will occur. If combustion does not occur within 15 seconds after the start switch is placed to the OFF position. Acceleration should occur smoothly with combustion to approximately 35 percent. At 35 percent you will notice a momentary lag. Unit speed will then increase sharply to near-governed speed. At approximately 95 percent of governed speed, the ready-to-load light (W) will illuminate, and the DC voltmeter (H) should indicate 28V DC.

When the ready-to-load indicator (W) glows green, you should set the AC contactor switch (O) to RESET, then to OPEN. Turn the voltage adjustment potentiometer (N) until 120V AC is obtained on the AC voltmeter (L). Check all three

phases of the AC output by rotating the phase selector (P) to each phase position. Observe the meters on the battery charger to insure that the batteries are being charged.

When you reset the AC system, you should also notice the engine rpm on the turbine speed indicator. Speed should now be stabilized at 100 percent. The frequency indicator (J) should be indicating 400 Hz.

It is only necessary to reset the DC system if there was no DC buildup indicated on the DC voltmeter at 95 percent. If necessary, reset the DC system by placing the DC contact switch (Q) to, first, the RESET, the second, to the OPEN positions. The DC voltmeter should then indicate 28V DC. If all instruments and lights are operating properly, the unit is ready for loading.

Loading. If both pneumatic and electrical loads are to be applied to the generator set, connect the pneumatic hose and the power cables to their respective connections on the aircraft. This action should be done prior to turning the bleed air switch (S), AC contactor switch, or DC contactor switch ON.

After the cables have been connected, place both the AC and DC contactor switches to the CLOSED positions. With AC contactor closed (M) and DC contactor closed (R), the indicator lamps will light. The AC and DC voltmeters should still be indicating 120V AC and 28V DC, respectively. The AC ammeter (I) and the DC ammeter (E) will not indicate any current flow until you have applied a load to the AC and DC generators. In order to do this, you should follow the instructions contained in the test set technical order, or instructions on the test set control panel.

After connecting the hose, turn the bleed air switch to the ON position. The bleed air ON indicator will light. Observe the bleed air pressure gauge (D), exhaust temperature indicator (X), and turbine speed indicator (B). The bleed air gauge should indicate approximately 35 psig. The exhaust temperature should not exceed 1300° F. The engine speed will drop slightly when a load is applied, but it will immediately return to rated speed. Although small AC and DC loads can be carried with a pneumatic load, in the event that the exhaust temperature exceeds 1180° F, the electrical load will be dropped. This will be indicated by the AC and DC contactor CLOSED indicator lights going out.

In the event that the exhaust temperature reaches 1300° F, discontinue loading of the generator set, but do not stop the engine. Allow the unit to operate without a load for a few minutes. This action reduces the thermal stress on the turbine wheel and other engine parts.

Shutdown. To stop loading of the generator set, turn the bleed air switch to OFF and the AC and DC contactor switches to OPEN. Allow

approximately 2 minutes for cooling, then set the master switch to the OFF position. The ready-to-load light will go out, and the engine will automatically slow down and stop.

The operating instructions contained in this text are for study purposes only. This text must not be construed to be the authority for operating instructions. Since the operating instructions are subject to change without notice, only the unit TO should be used when actually operating the generator set.

Exercises (268):

1. List at least four hazards which are present when the -60 generator set is operated.
2. In what two ways may the 60 generator set engine be stopped in the event of an emergency?
3. State two reasons why the AC system must be reset when the engine rpm reaches 95 percent of governed speed.
4. Why is it important to use only the unit TO when following the prescribed operating instructions?
5. What action should be taken if the electrical load is dropped and the bleed air system continues to operate with the exhaust gas temperature at 1300° F?
6. What action should be taken if combustion did not occur within 15 seconds after the start switch was placed on?
7. When will the ready-to-load light illuminate?
8. When is resetting the DC system necessary?

Shop Equipment

THE PNEUDRAULIC mechanic also performs maintenance that requires the use of shop equipment. His duties in the pneudraulic shop, for example, are to repair hydraulic components. Before a component is repaired, it must be cleaned. After it is repaired, it must be tested. The test will tell us if it is working correctly or if it needs further adjustment.

In order to perform these tests, the shop must be equipped with the proper test stands and testing devices. The equipment authorized for a shop varies and usually depends on the level of maintenance to be done in the shop. If maintenance consists of only removal and replacement of parts, little special test equipment is needed. Where units are completely overhauled, complex machines made to service test the units are needed.

To perform the duties of your specialty you will use many kinds of shop equipment. Naturally, you must know how they work. You must know how to use them correctly, and you must know how to maintain them. This chapter will give you some of the knowledge you need for these duties.

6-1. HCT-6 Hydraulic Component Tester

An overall view of the HCT-6 is shown in figure 6-1. This nonportable hydraulic test stand is standard equipment in most pneudraulic shops. The stand has five hydraulic testing circuits to provide either a dynamic or static test of components. The limits on what can be tested are determined by the range of the component being used. Some examples of components that can be tested are actuating cylinders, hand pumps, power pump, and relief valves. The appropriate technical order indicates the type of test required. The hydraulic systems of the HCT-6 supply fluid at controlled temperature, pressure, and flow rates to the outlets. The power supply and control components will be covered in the system which they serve.

Most of the following objectives will be referenced to the schematic on the HCT-6 in foldout 2. Turn to foldout 2 now and briefly look at the schematic.

269. Identify the five major test circuits and specify the constructional and operational features of each.

Major Test Circuits. The HCT-6 test stand has five major test circuits that are supplied with fluid flow from three internally installed pumps. The five test circuits, as shown in figure 6-2, are the component test circuit, actuator cylinder test circuit, pump test circuit, static test circuit, and high-pressure test circuit. Certain circuits were designed to check out specific components, while other circuits can be used to check out a variety of components. The tests conducted are classified as static (not moving) and dynamic (moving).

Component test circuit. This circuit gets hydraulic fluid, under pressure, from the internal high-pressure pump circuit. The circuit is used to statically or dynamically test components like filters and valves. The type of test (static or dynamic) done will depend on how the part is hooked to the test stand. The circuit, refer to foldout 2, consists of component test circuit outlets (25 and 27) and their respective shutoff valves (24 and 26). These valves are pressure-balanced-spool-type units. This allows them to be operated against 3000 psi as easily as against 0 psi. Flow through the component test circuit return inlets (28 or 30) is controlled by their respective return shutoff valves (29 and 31). Note in the foldout that return inlet (30) sends the return flow through the flowmeter (33). If it is not necessary to measure the return flow, then use return inlet (28) that is connected directly to the reservoir (1) and bypasses the flowmeter (33). Because the return circuit is a complex circuit in itself, it will be covered separately later.

Cylinder test circuit. This circuit is also pressurized by the internal high-pressure pump circuit. It is primarily used to test units, such as actuating cylinder dynamically. Refer to foldout 2 as we go through this circuit. Opening the shutoff valve (37) will direct fluid to the open center selector valve (38). It, in turn, directs fluid to the CYL 1 position outlet (39) or to the CYL 2 position outlet (40). NOTE: When using the cylinder circuit selector valve (38), close the shutoff valve (37) before the position of the selector valve is changed. The third position, FLOWMETER RETURN, is the neutral position of this open center selector valve (38). This position connects the internal high-pressure pump circuit to the

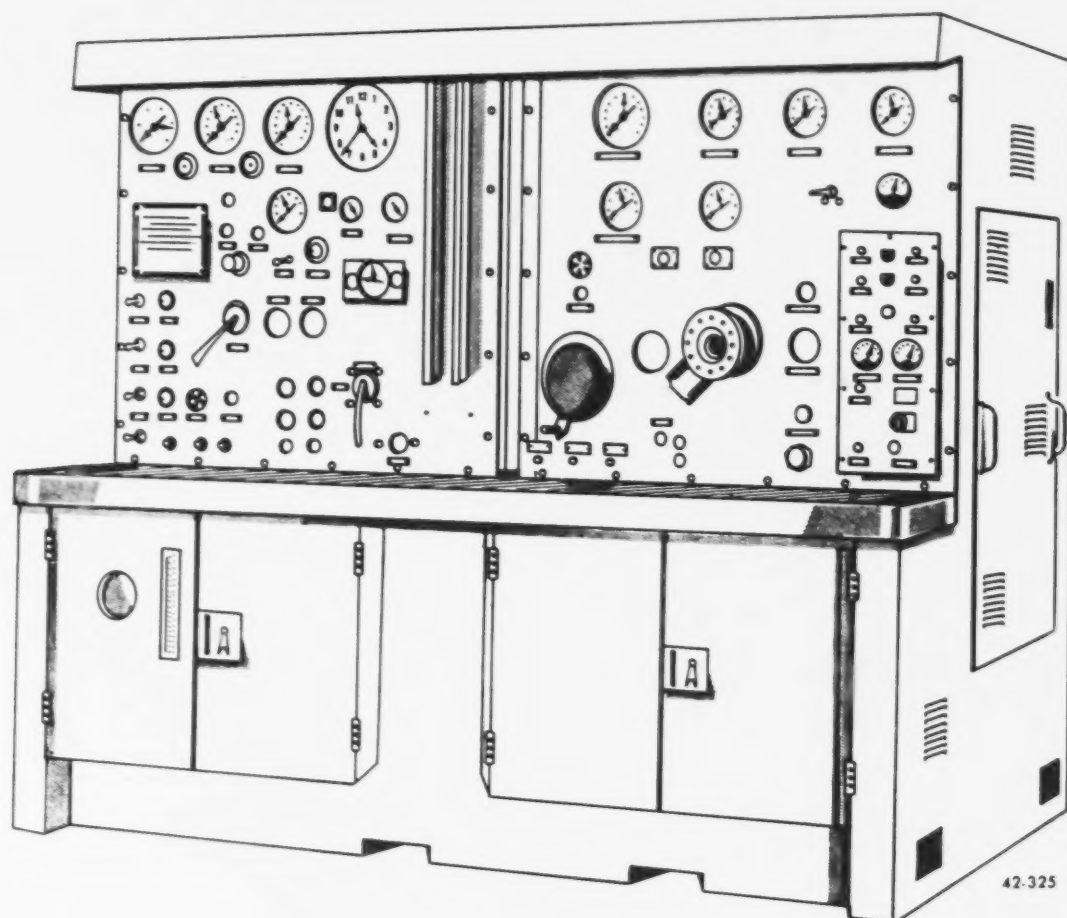


Figure 6-1. HCT-6 hydraulic component test stand.

flowmeters (33) in the return circuit. The FLOWMETER RETURN position, in turn, blocks the CYL 1 and CYL 2 outlets (39 and 40). The selector valve must be in this position when you adjust the volume output of the stand. A check valve (12) is placed in the return line downstream of the selector valve to prevent a reverse flow.

Pump test circuit. This circuit is used to test engine-driven pumps. The pump test circuit is schematically shown in the lower right-hand portion of foldout 2. The pump suction port is connected to the appropriate outlet (64). Fluid supply to the pump is controlled by a pump test inlet pressure regulator (62). This is a pilot-operated relief-valve pressure regulator. The pump test inlet pressure regulator will keep the set pressure as speed and flow are varied. This will prevent damage to the pump under test by either a high or a low supply pressure.

A suction flow indicator (63) gives the operator a visual indication of flow to the pump inlet. The pressure port of the pump is hooked to the pump test pressure return inlet (70). The pump output pressure is shown on the 0- to 6000-psi gauge (71). As the pressure in the pump test circuit return line goes above 125 psi, the pressure switch (72) closes. The switch energizes the bypass valve (14) to the OPEN position. This will cause the fluid that is being pumped by the internal high-pressure pump (9) to be bypassed into the return circuit. Thus, a minimum of power is needed for turning the pump. Keep in mind that the high-pressure pump (9) is driven by the same electric motor that drives the pump test pad. However, this reduction in power is necessary only when the pump test pad is rotated in a counterclockwise direction. This is also the normal direction of rotation of the internal highpressure pump (9). When the pump pad is

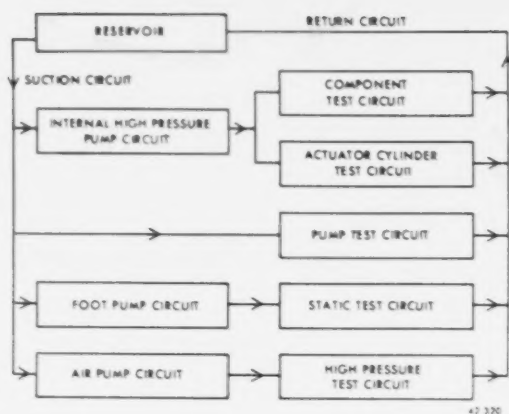


Figure 6-2. Major test circuits.

turned in a clockwise direction, the bypass valve (14) will still be energized to the OPEN position by the pressure switch (72). No fluid will be circulated because the direction of rotation is opposite to the normal rotation of the internal high-pressure pump (9). Note in the foldout 2 that the pump return circuit is protected from excessive pressures by the pump test relief valve (73). This relief valve can be adjusted (same as the internal high-pressure pump circuit relief valve) from 500 to 5000 psi. The pump test throttling valve (74) allows the operator to regulate the pressure in the pump test circuit. He does this by restricting the fluid flow to the return. From here the fluid flow is directed into the return circuit. This circuit will be covered at a later time.

The scavenge flowmeter circuit is basically a portion of the return circuit, but is primarily used with the pump test circuit. This circuit is shown in the upper right-hand portion of foldout 2. It measures the fluid from the case drain port of the pump under test to check for internal leakage. The pump case drain port is connected to the scavenge flowmeter inlet (75). The fluid flow is controlled by the scavenge flowmeter shutoff valve (76). This valve also regulates the case pressure of the pump under test by restricting fluid flow. From here the fluid is directed to the scavenge flowmeter (77), which has a capacity of 0.14 to 1.5 gpm. Connect the pump case drain port to the component test return circuit inlet (30) if the flow is greater than 1.5 gpm. This will allow the pump case drain line flow to be directed to the larger flowmeter (33) used in this circuit. A check valve (78) is installed downstream of the scavenge flowmeter (77) to prevent reverse flow because of reservoir pressurization.

Foot pump test circuit. This circuit allows the operator to perform static tests on components with pressures up to 6000 psi. The foot pump (41) is a

single-suction single-action pump. It supplies fluid under pressure to the foot pump circuit pressure manifold. The relief valve (43) is installed to protect the system from possible overpressurization. It is factory set at 6000 psi and is not adjustable. A foot pump bypass valve (42) is also installed to allow depressurization upon completion of testing. The foot pump pressure can be directed to the component and actuator test circuits by opening the shutoff valve (44). The internal high-pressure pump will pressurize the foot pump circuit if the shutoff valve (44) is left open. The pressure in this circuit is indicated on the foot pump pressure gauge (45). Pressure is then directed to the foot pump outlet shutoff valve (46). This valve controls the flow to pressure outlet (47) which is connected to the component being tested.

In other instances, this outlet (47) is used to measure the return or back pressures of many components being tested. For example, when testing a hand pump for proper operation, the suction port is connected to suction outlet (49). Place the suction outlet shutoff valve (48) in the OPEN position. The pressure port of the hand pump is hooked to the foot pump pressure outlet (47). This allows the foot pump pressure gauge (45) to show the pressure developed by the hand pump. The gauge shutoff valve (45A) and the pressure outlet shutoff valve (46) must be in the OPEN position during operation.

The foot pump circuit may also be used to perform a leakage test on various components. The nonpressurized side of the unit being tested is hooked to the leakage tank (51) through the inlet (50). The leakage tank (51) has a sight gauge that shows leakage from 5cc to 400cc, and 1 to 24 cubic inches. This tank is vented to prevent it from becoming pressurized, and can be drained by opening the drain valve (52).

High-pressure air pump circuit. This circuit is schematically shown as being located just above the pump test suction circuit, see foldout 2. It is used to perform static tests on hydraulic components at extremely high pressures. The air-operated pump circuit is capable of generating 25,000-psi hydraulic pressure when supplied with 100-psi air pressure.

Filtered air is supplied from the shop's air source. Pressure regulator (53) controls the output pressure of the air pump (56) and is adjustable from 0 to 100 psi. The pressure gauge (54) shows the air pressure applied. The lubricator (55) found between the pump air inlet and regulator provides lubrication for the air pump (56). It is serviced with 30-weight engine oil. The air pump is a differential piston-type unit having a ratio of 250 to 1. The exhaust port of the pump is also equipped with a muffler (57) to deaden the noise of the exhaust.

The air pump pressure gauge (58) shows the output pressure of the pump from 0 to 25,000 psi. The gauge is hooked to a gauge shutoff valve (58A)

and outlet vent shutoff valve (59). The outlet vent shutoff valve is used to release the pressure from the high-pressure test circuit. The flow from the high-pressure circuit is directed through shutoff valve (60) and air pump outlet (61) to which the component being tested is connected. The circuit uses a very small volume of fluid. When pressure is released fluid is dumped into the sink tray.

There are many other circuits that are used to support these major circuits. Each of these will be discussed in the following paragraphs.

Exercises (269):

1. Match the test circuit and outlets shown in column B to the statement in column A that specifies the constructional and operational features of each. You may use foldout 2 if it is needed. The items in column B can be used more than once.

Column A

1. An actuating cylinder that is to be tested should be connected to either of these outlets.
2. Used to statically or dynamically test components like filters and valves.
3. Used to test engine-driven pumps.
4. This outlet is used to test components by using foot pump.
5. Primarily used to test actuating cylinders dynamically.
6. Flow through this circuit's inlet valves is controlled by the inlet valves return shutoff valves.
7. This test circuit is used to perform static tests in components with pressures up to 6000 psi.
8. A suction flow indicator (63 on foldout 2) gives the operator a visual indication of the flow to the pump inlet in this test circuit.
9. This test circuit is used to perform static tests on hydraulic components at extremely high pressures.
10. A three-way selector valve that must be tested should be hooked to either of these two outlets.
11. In this test circuit the exhaust port of the pump has a muffler (57 on foldout 2) to deaden the exhaust noise.

Column B

- a. Cylinder test circuit.
- b. Foot pump test circuit.
- c. High-pressure air pump circuit.
- d. Component test circuit.
- e. Pump test circuit.
- f. Outlets 25 or 27.
- g. Outlets 39 or 40.
- h. Outlet 64.
- i. Outlet 47.

270. Using foldout 2, indicate whether given statements correctly reflect the purpose and operational characteristics of the HCT-6 support circuits.

Air Pressure Circuit. This circuit is schematically shown in the left-hand portion of foldout 2. The air pressure circuit supplies shop air to the four pressure regulators built into the test stand.

Shop air (at least 90 psi) enters the stand through inlet (89), flows through a shutoff valve (88), filter (87), and to four pressure regulators (90, 97, 53, and 85). Each of these regulators will be explained in more detail later on in this chapter. The air pressure at this point will be shown on the air inlet pressure gauge (86). Note that this gauge, like all other gauges on the stand, is equipped with a shutoff valve (86A) and a test port (86B).

Suction Supply Circuit. The suction supply circuit provides the necessary fluid to the five test circuits as shown in figure 6-2. This circuit stores hydraulic fluid in the reservoir (1) shown in the left-hand center portion of foldout 2. A reservoir fluid level sight gauge (3) is found on the front of the reservoir. The reservoir is also equipped with heaters that will hold the fluid temperatures between 70° F and 170° F. You set the reservoir heater control switch (94) to the temperature setting you want. The temperature will be shown on the temperature gauge (95). These heaters raise the temperature from 60° F to 100° F in 15 minutes with 25 gallons of fluid in the reservoir. A reservoir level switch (110) is installed in the reservoir. This switch turns off the heaters if the fluid drops below the $\frac{3}{4}$ level. A reservoir heater switch (111) on the control panel allows for manual operation of the heaters. The reservoir has a rated capacity of 25 gallons of fluid and can be pressurized from 0 to 125 psi.

The reservoir gets its air pressure from an external shop source. Pressurization from the air pressure circuit is held between 3 and 125 psi by the air pressure regulator (90). A reservoir pressure selector valve (92) allows the operator either to pressurize or vent the reservoir to the atmosphere. The pressure within the reservoir is shown on the 0- to 160-psi reservoir pressure gauge (91). The gauge is equipped with a gauge shutoff valve (91A) and a test port (91B). The relief valve (93) installed in the pressure line is set at 125 psi. It prevents the pressure from exceeding the rated working pressure of the reservoir.

Fluid from the reservoir (1) passes through a shutoff valve (5) and a suction line filter (6) where foreign particles are removed. The filter relief valve (18) is set at 50 psi. The filter element is bypassed by the fluid in the event it becomes clogged. The schematic shows the bypass valve as being a separate unit; however, it is an integral part of the filter housing. The filter pressure switch (7) will light a lamp on the panel whenever the filter becomes clogged. This switch is not factory set and is to be adjusted in accordance with base SOPs. The air bleed valve (17) is installed at the highest point in the suction circuit to vent it of the air. The

low suction pressure switch (8) stops the pump motor whenever a vacuum develops in the suction circuit. It is set to open when the pressure drops to 7 inches of Hg (mercury).

Internal High-Pressure Pump Circuit. This circuit consists of the usual supply power/source and regulating systems found in any other hydraulic system. It supplies hydraulic fluid at controlled pressures and flow to the component and cylinder test circuits.

The variable-volume, pressure-compensated, piston-type pump (9) is driven by an electrical motor rated at 30 hp. This pump has a rated capacity of 15 gpm at 3000 psi or 10 gpm at 5000 psi. Fluid is drawn from the reservoir and delivered under pressure to the pressure manifold. A volume control (10) and a pressure compensator (11) permit setting the pump to meet testing requirements. The check valve (12) installed downstream of the pump prevents excessive back pressures from hurting the pump. After flow passes the check valve, the fluid is directed to the test stand relief valve (13). This valve can be adjusted from 500 to 5000 psi to limit the maximum system operating pressure. The valve should be adjusted from 200 to 400 psi higher than the maximum test pressure. Never adjust it below 500 psi as damage to its seals may result. The solenoid-operated bypass valve (14) is installed in the system so that it can be depressurized. This is done by moving a toggle switch on the control panel. This valve is also operated by the pressure switch (72) that is installed in the pump test circuit. A check valve (108) is installed downstream of the sensing element in the flowmeter outlet line to prevent damage to the flowmeter when the solenoid bypass valve (14) is operated. Incorporated in the pressure manifold is a 0- to 6000-psi test pressure gauge (19). It records the system pressure for both the component and cylinder test circuits. The gauge shutoff valve (19A) isolates the gauges from the hydraulic system during calibration and service. The test port (19B) allows the the gauge to be calibrated without removing it from the stand. (Every gauge on this stand is equipped with a shutoff valve and test port; all shutoff valves are kept in the OPEN position during normal operation.) Downstream of the pressure gauge is a 200-cubic-inch accumulator (20). This unit absorbs pressure surges and pump pulsations. The accumulator shutoff valve (21) is used to isolate the accumulator from the circuit. The accumulator should be charged with nitrogen to 1500 psi through the accumulator charging circuit. It consists of a charging valve (23), pressure gauge (22), gauge shutoff valve (22A), and the gauge test port (22B).

Return Circuit. This circuit provides a path for return flow back to the reservoir from all the test stand circuits. It is equipped with associated valves that will clean, cool, and measure the return fluid.

Any of the six return outlets shown in the upper right-hand portion of foldout 2 can be used. The return fluid can be measured in the flowmeter (33) except when the flow is directed through the component No. 1 return inlet (28). Notice that this inlet is connected to the downstream side of the flowmeter (33).

The flowmeter (33) is actually two flowmeters in one housing. The smaller flowmeter of the dual unit has a range of 0.4 to 4 gpm. The larger has a range of 2.5 to 25 gpm. Fluid flow can be directed through either flowmeter by positioning the range selector valve (32) properly. As a safety precaution, always position this valve to the larger volume setting when shutting down the test stand. The two flowmeters are protected against excessive pressures by the flowmeter relief valve (34). It is set to relieve at 120 psi. The relief valve flow indicator (35) enables the operator to see when the relief valve opens. Check valve (36) prevents reverse flow resulting from reservoir pressurization. This line is connected directly to the reservoir.

Notice that downstream of the flowmeter, a sensing element measures the temperature of the fluid. From here the fluid is directed to the return line filter (15) that removes any foreign matter. The filter is equipped with a differential pressure switch (7). Anytime the filter becomes clogged, it causes a light on the control panel to illuminate. The bleed valve (17) allows entrapped air to be bled from the return circuit. Since the filter is not equipped with an internal bypass, a relief valve (109) is installed. The relief valve is set at 50 psi.

Before entering the reservoir, the fluid passes through a heat exchanger (16). It is a water-cooled shell-and-tube type. The fluid passes through the heat exchanger and is cooled by the flow of cooling water. The temperature control circuit maintains the desired temperature.

Temperature Control Circuit. The circuit is schematically shown in the upper left-hand corner of foldout 2. The temperature control circuit is designed to maintain the fluid at a constant temperature of 100° F to 180° F. This is done by cooling the fluid with the heat exchanger (16), or heating the fluid with the heaters in the reservoir.

The fluid temperature controller (96) is a pneumatic indicating assembly. It is equipped with two air pressure gauges and a temperature gauge. This temperature gauge is connected to the return line sensing element. It shows the temperature of the fluid passing through the return circuit. The input gauge (left) shows the input air pressure which is normally maintained at 20 psi, controlled by the air pressure regulator (97). The output gauge (right) shows the amount of air pressure applied to the diaphragm of the air-operated shutoff valve (98). Shutoff valve (98) controls the flow of cooling water to the heat exchanger (16).

Water for the heat exchanger enters the test stand through the inlet provided (101). Water inlet valve (100) is used to turn the water on and off. This valve should always be open except when maintenance is being performed on the stand. The water flows through water pump (99) which is equipped with a removable 60/80 wire mesh screen and a drain plug. The water then flows through the heat exchanger (16), and back out of the test stand through the outlet (102). The capacity of the water supply to the stand must be 15 to 20 gallons per minute.

Manometer Circuit. This circuit is schematically located immediately above the pump test suction circuit. The manometer circuit is primarily used in conjunction with the pump test. It measures the inlet pressure or vacuum to the hydraulic pump under test. However, it can also be used independently to measure the vacuum of vacuum pumps.

The first unit in the manometer circuit is the pump test manometer shutoff valve (65). This valve allows the operator to isolate the circuit whenever desired. An air bleed valve (17) is installed in the manometer inlet line to remove air from this part of the circuit. The 30-inch U-type manometer (66) is half filled with mercury. It is direct reading and is calibrated from 0 to 30 inches Hg. Either pressure or vacuum can be measured with the manometer (66). A float-type check valve (67) is installed in the manometer outlet. It prevents the mercury from being blown out if the pressure exceeds 30 inches Hg. It also serves as a vent during normal operation.

The pump under test will generally be connected to the pump test outlet (64). The inlet flow will be controlled by the pump test inlet pressure regulator (62). Whenever the circuit is used independently, the component will be connected to the manometer outlet (69). The manometer outlet shutoff valve (68) controls flow to the manometer. The manometer should be isolated from the circuit anytime the suction pressure of the pump under test is greater than 30 inches Hg. This prevents damage since the manometer is only rated to 30 inches Hg.

Vacuum Circuit. This circuit is schematically shown just below the air pressure circuit. The vacuum circuit is used when testing the pump shaft seal. Vacuum pressure is generated by a rotary-type vacuum pump (83). This pump can generate 27 inches of Hg vacuum. It is equipped with an automatic oiler that is serviced with 30-weight engine oil. The test pad selector valve (80) allows the operator to connect the test pad outlet (79) to pressure, vacuum, or atmosphere.

Air pressure is on the test pad pressure gauge (84) when the regulator valve (85) is opened. The vacuum pressure is shown on the test pad vacuum gauge (81), which reads from 0 to 30 inches of Hg vacuum. The level of vacuum pressure in this circuit is controlled by the position of the vacuum

regulator (82). When this valve is opened, atmosphere can enter the system, thus reducing the level of vacuum.

Exercises (270):

Indicate whether the following statements correctly reflect the purpose and operational characteristics of the HCT-6 support circuits by placing the letter T alongside the true statements and an F alongside the false statements. You may use foldout 2.

- 1. A volume control and a pressure compensator are used to set the internal high pressure pump to meet the test requirements.
- 2. The return circuit is used to test the pump shaft seal.
- 3. Pressure gauge 86 on foldout 2 shows air pressure circuit inlet pressure.
- 4. The reservoir has heaters that will hold the hydraulic fluid temperature between 70° F and 170° F.
- 5. The differential pressure switch (item 7 on foldout 2) is in the suction supply circuit, and will turn a light on the panel "on" whenever the suction filter becomes clogged.
- 6. The accumulator in the internal high-pressure pump circuit should be changed with nitrogen to 3,000 psi.
- 7. The return circuit provides a return path back to the reservoir for all test stand circuits.
- 8. Both flowmeters in the return circuit have a range of 2.5 to 25 gpm.
- 9. The fluid that passes through the heat exchanger (16 on foldout 2) is cooled by the flow of air.
- 10. The temperature control circuit is designed to maintain the hydraulic fluid at a constant temperature of 100° F to 180° F.

271. Specify the operating procedures, troubleshooting procedures, and the inspections required on the HCT-6 hydraulic test stand.

Operating Instructions. You should have little difficulty in operating the HCT-6 test machine. Knowing the various test circuits is a great asset in using the machine. Therefore, we shall use the machine's schematic diagram (foldout 2) during our discussion of its operation. This will also give you a better understanding of why the various valves, etc., are being turned. Bear in mind that there are various procedures that can be used when operating this machine. The particular procedure used depend primarily on the types of units that are going to be tested. Thus, we shall make our

discussion about the operation of the test machine as simple as possible.

Setting up the test machine. When you test a unit, one of your first concerns is to select the proper connecting hose or tubing. The hose used must be able to withstand pressure used during the test operation. Otherwise, you might find yourself cleaning up hydraulic fluid that has sprayed on the ceiling and the walls of the shop. When all of the hookups have been made and the machine has been checked for irregularities, you are ready to set it up. First, open all the gauges shutoff valves and the cylinder circuit shutoff valve. Opening the cylinder circuit shutoff valve (37) allows the pump output to flow through the neutral position selector valve (38), through the flowmeter (33), and on to the reservoir. This flow will take the load off the pump. Next, open the reservoir shutoff valve (5), the water shutoff valve (100), and the air inlet shutoff valve (88). All the other valves on the instrument panel should be closed. Position the actuating cylinder test circuit selector valve (38) to the FLOWMETER RETURN position. Set the flowmeter range selector (32) to the 2.5 to 25 gpm position. This latter action will allow the fluid output of the high-pressure pump (9) to be directed to the reservoir through the larger flowmeter (33). This will be necessary when you adjust the volume output later on. Using the air pressure circuit, pressurize the reservoir (1) to 25 psi; then, depressurize the reservoir and check the fluid level. The purpose of this operation is to insure that all lines are completely filled with fluid. After this has been done, repressurize the reservoir to 60 psi. You are now ready to start the machine.

Starting. At this point, close the main circuit breaker, then turn on the master switch. Next, place the bypass valve switch to the ON position. This latter action will open the bypass valve (42), allowing the pump (9) to start in a NO load condition. Now, press the counterclockwise button to start the stand and the internal pump. Then return the bypass valve switch to the OFF position. This last action closes the bypass valve, and causes the pump to circulate the fluid through the system. Be sure to set the reservoir heater control (94) to the desired temperature and to turn on the switch (111). As the fluid approaches the chosen temperature, reset the heater control to 70° F. Unless you want a high temperature, it is not necessary to use the heaters during a test. Next, set the red pointer of the fluid temperature controller (96) to the temperature you want. Allows the pump to circulate the fluid through the reservoir and return circuits until the fluid temperature is at the setting you have made. After this temperature has been reached, press the motor control stop button to stop the pump, then turn the bypass valve switch back to ON.

Adjustment to aircraft component requirements. In order to properly check out an aircraft

component, you must adjust the test stand to the required gallon per minute volume and pounds per square inch pressure. These requirements can be found in the test section of the overhaul instructions TO for each component.

After you have gone through the initial startup procedures, start the stand internal pump (counterclockwise rotation). Once the pump is turning, close the bypass valve. Next, adjust the volume control on the internal pump. Access to this pump is gained through the rear maintenance access doors. This entire procedure must be carried out with the cylinder circuit shutoff valve (37) set to open, and the selector (38) in the flowmeter return position.

When you have obtained the desired gpm flow, close the cylinder test circuit shutoff valve, then adjust the compensator control all of the way in. Follow this by adjusting the system relief valve (13) to the desired pressure plus 10 percent.

When the relief valve has been set, adjust the compensator control back to out to the desired pressure. Now you are finally ready to test the component.

Troubleshooting. When there is a malfunction of any portion of the test stand, always check the startup and operating procedures given in TO 33A2-2-35-1, the TO on the HCT-6 test stand. Do this to make sure that the malfunction is not due to an incorrect valve or switch positions. If the drive will not start, check to see whether or not the master switch on the electrical control panel is turned on, and that all circuit breakers have been closed.

If the malfunction occurs during operation of the stand, and you find that all valves are in the proper position, go to the schematic of the system located on the front of the stand, to see if you can determine the most probable cause. For example, suppose that the pump fails to deliver sufficient pressure. There are a number of probable causes for this failure. Just to list a few: the compensator control may be improperly set; the relief valve improperly set; the pump compensator defective; or the bypass valve leaking internally. Each of these probable causes must be checked. The easiest way to do this is to go from the simplest to the most complex possible cause. Thus, start with the relief valve, checking its adjustment. If it is bypassing fluid internally, you can usually hear it do this. After this possible cause has been eliminated, check the compensator control to see whether or not the adjustment has backed out. Failure to lock it into place securely will allow it to vibrate out during pump operation. If the compensator is defective, you must change or repair it before you continue your troubleshooting.

If you cannot determine the probable cause by studying the schematic, there is a troubleshooting chart in the applicable TO (332A-2-35-1).

Maintenance. Because this test stand is used to check all parts repaired in the shop, its maintenance is very important to you as a mechanic. In order to prevent malfunctions, the TO lists four types of inspections: daily, semimonthly, 4-month, and yearly.

Daily inspection. Daily inspections are minor. Each day gauges are checked for calibration. Also, gauge faces are checked for cracks. In addition, the reservoir is checked to make sure that it is full. If you find any discrepancies during this time, repair them.

Semimonthly inspection. This inspection of course includes the daily inspection. Make a general inspection to insure the safety and efficiency of operation of the test stand. Repair all defects you note.

The 4-month and yearly inspections. Both of these inspections are all inclusive of the preceding inspections, with additional checks made to insure that the stand is operating properly and that it is safe for persons to use. There is a listing of these inspections, along with their required checks, given in TO 332A-2-35-1. This concludes our discussion of the stationary test stand.

Exercises (271):

1. Why is the selecting of the proper hose or tubing for connecting components to be tested so important?
2. Why is the flowmeter selector valve (32) set to the 2.5 to 25 gpm position when first starting the test stand?
3. Why is it important to pressurize, depressurize, then repressurize the reservoir?
4. In which position is the cylinder circuit shutoff valve (37) and the flowmeter selector valve (38) set in order to adjust the volume of the internal high-pressure pump?
5. What is one of the first things you should do if you found a malfunction on the hydraulic test stand?

6. The compensator valve is preventing the pressure from building up because it has backed out. What could have prevented this from happening?

7. What are the four types of inspections that are performed on the HCT-6 test stand?

6-2. Hose Manufacturing Machines

Less than 20 years ago manufacturing a hose assembly was quite a job. You had to cut the hose with a hacksaw, then assemble the individual pieces of the hose assembly by hand. If you had to manufacture one or two hose assemblies per day this wasn't too bad, but when a work order came in to manufacture 20 or more hoses, it was terrible. In many isolated shops even today, hoses are still being done in this manner. Other shops have machines to cut and assemble hose assemblies. This has improved the quality of the hose being manufactured, and at the same time has saved many man-hours. Two machines that you will find in most pneumatic shops are the hose cutoff and skiving machine and the hose assembly machine.

272. Specify the general characteristics of the hose cutting and skiving machine, and the safe procedures of cutting skiving a hose.

The Hose Cutting and Skiving Machine. This machine is designed to cut and skive hose (remove outer material down to wire braid) in preparation for installing hose fittings. The equipment will cut all types of hose, including high-pressure double-wire braided up to 3 inches internal diameter, and will skive wire-braided hose of 3/16-inch through 2-inch internal diameter. The drive motor (figure 6-3) has a 3-horse power rating at 2900 rpm, and operates from a 220-volt, 3-phase, 60-cps power source. The armature shaft extends out each end of the motor housing. The skiving brush is mounted on one end, and a pulley is mounted on the other for driving the belt-driven cutting blade. The pushbutton control (figure 6-3), on front of the machine, is a thermal overload type containing two pushbutton switches, START and STOP RESET. Depressing the START switch starts the drive motor, and depressing the STOP RESET switch stops the motor or resets the tripped overload relay. The thermal overload relay trips to interrupt power to the drive motor if the motor exceeds full-load current by an excessive amount. Primary components are hose cutting section and the hose skiving section.

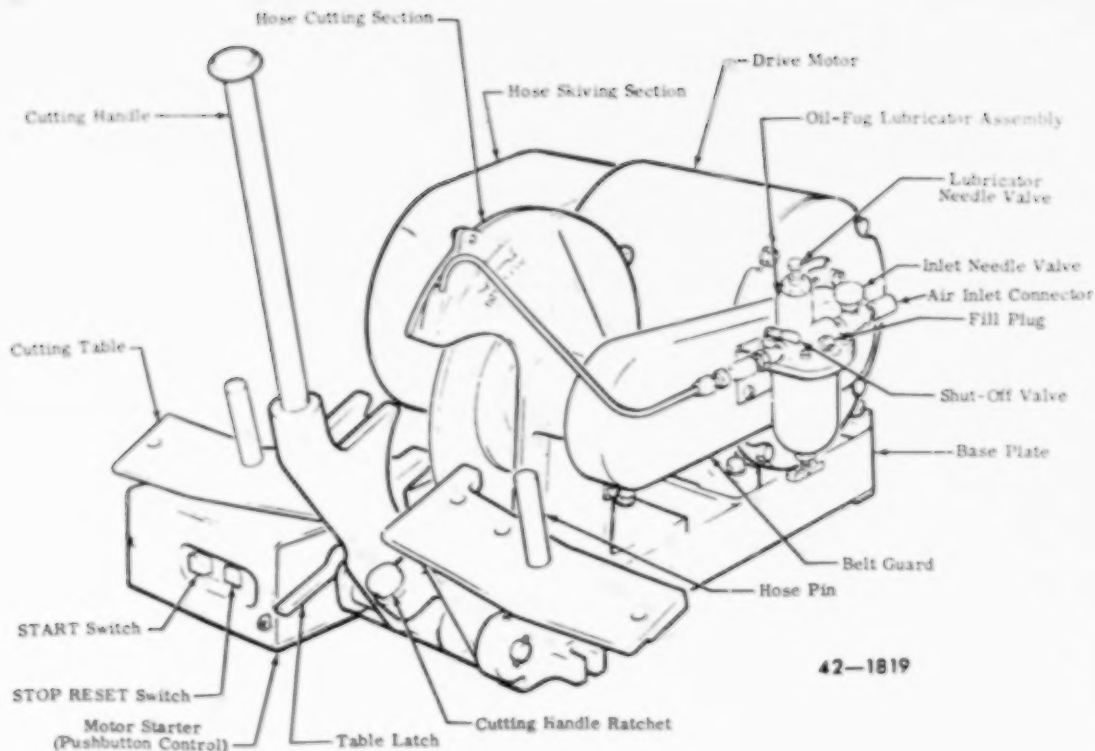


Figure 6-3. Hose cutting and skiving machine.

Hose cutting section. The hose cutting section (figure 6-3) consists of a 10-inch diameter, belt-driven cutoff knife blade (cutting blade), cutoff knife bracket and guard, cutting table, cutting handle, and coolant system. The cutoff knife bracket and guard support the blade and shaft and provide a housing that covers all but a small portion of the blade to protect the operator from flying particles. The cutting table that provides a flat support for the hose during cutting is equipped with movable pins. The pins (figure 6-4), in conjunction with the cutting handle, secure the hose at the desired cutting radius. A self-engaging latch secures the table in the loading (retracted) position. The cutting handle is also used to feed the table and hose into the blade during cutting. A ratchet equipped with a manual release locks the handle to the table to secure the hose in position. The coolant system supplies an oil-fog to cool and lubricate the blade during cutting operations. The system is air operated and includes an oil-fog lubricator, connecting lines, valve, and fittings.

Hose skiving section. The hose skiving section (figure 6-5) consists of skiving brush, brush guard, mandrel plate, and mandrel plateholder. The skiving brush is mounted on the motor shaft, and the mandrel plate that is equipped with six

mandrels is mounted on the mandrel plateholder. The mandrel plate can be rotated to position a selected mandrel adjacent to the skiving brush. A pawl on the mandrel plateholder provides a means for releasing the plate for rotation and for locking it in the desired position. An adjusting screw attached to the mandrel plateholder permits adjustment of the clearance between the skiving brush and mandrel. The skiving brush guard has an outlet to which an exhaust system can be attached for scavenging the skiving section.

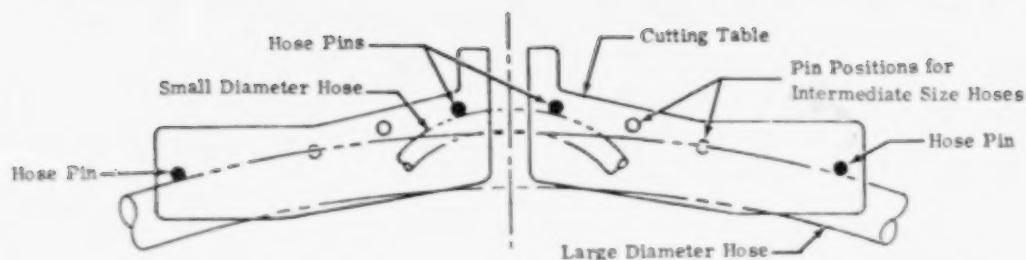
Operating instructions for cutting hose. A normal cutting operation is performed when the hose is long enough and of sufficient diameter and rigidity to be held in position by the hose pins and cutting handle.

CAUTION: Wear safety glasses or goggles during cutting operations to protect eyes from flying particles. Keep hands clear of the blade to avoid serious hand injuries.

(1) Check the lubricant supply in the oil-fog lubricator and add lubricant as necessary.

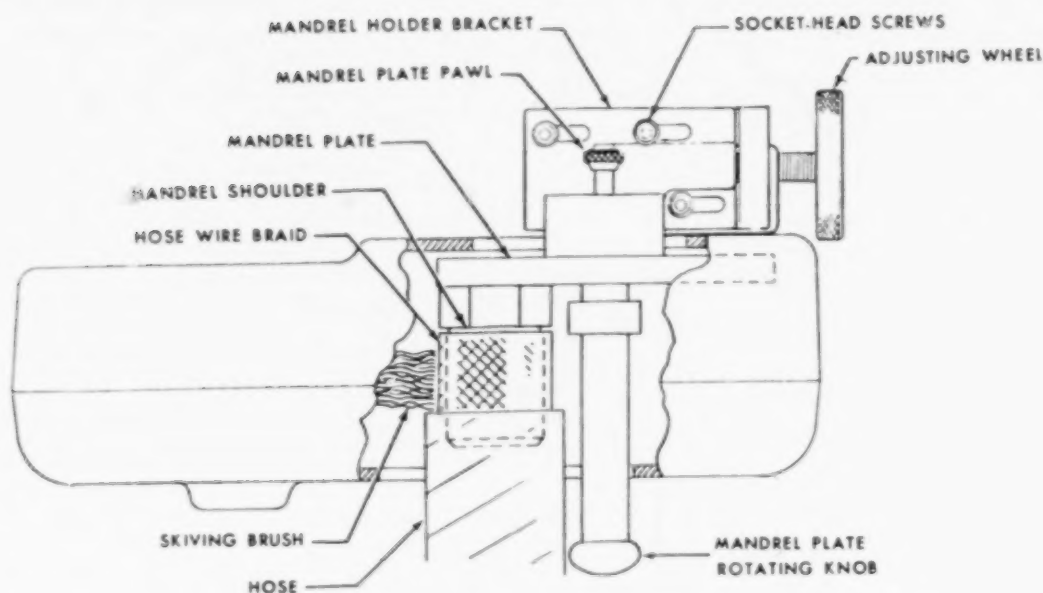
(2) Place the cutting table in the loading position (away from blade with table latch engaged).

(3) Move the cutting handle to the full retracted position (pull up on the ratchet release knob to release the handle.)



42-1821

Figure 6-4. Hose cutting table.



42-1818

Figure 6-5. Hose skiving section.

(4) Install the movable hose pins in the cutting table according to size of the hose to be cut, as indicated in figure 6-6.

(5) Mark the hose at the point where the cut is to be made, and place the hose on the cutting table between the pins and handle, with the mark aligned with the blade.

(6) Move the handle toward the blade to force the hose into the correct cutting arc. This causes the cut surfaces to spread away from the blade to prevent binding and blade overheating. When the correct arc is attained, release the handle; the ratchet will hold the handle and hose in position.

(7) Depress the START switch on pushbutton control to start the motor. Open the coolant system shutoff valve.

(8) Release the cutting table by depressing the table latch, and cut the hose by moving the table and hose forward to the blade by means of the cutting handle.

(9) Move the table away from the blade until the latch engages, and remove the hose. Pull up on the ratchet release knob, and fully retract the cutting handle.

(10) Press the STOP RESET switch to stop the motor. Close the coolant system shutoff valve. With the hose cut, the next step is to skive it.

Hose Internal Diameter	Radius of Bend	Hose Pin Location
1/2 inch and smaller	1 in	1st set of holes nearest blade
1 inch and 3/4 inch	2 to 4 inches	2nd set of holes nearest blade
1 1/4 and 1 1/2 inches	4 to 6 inches	3rd set of holes away from blade
2 inches	6 to 8 inches	Outside set of holes

42-1825

Figure 6-6 Hose pin location.

Operating instructions for skiving. The skiving operation should remove all the outer material from the hose down to the wire braid. After skiving, the wire braid should appear bright, but the individual wires should not be disturbed. The length of skiving is determined by the shoulders on the mandrels and is not adjustable (see figure 6-5).

WARNING: Wear safety glasses or goggles during skiving operations to protect the eyes from flying particles. Keep hands clear of rotating skiving brush to avoid serious hand injuries.

(1) With the STOP RESET switch depressed (equipment not operating), select the mandrel which fits the internal diameter of the hose to be skived. Pull out the mandrel indexing pawl and, by means of the mandrel plate rotating knob, rotate the selected mandrel adjacent to the skiving brush. Release the pawl to lock the mandrel in the correct position.

(2) Loosen the three socket-head screws securing the mandrel plate holder bracket. Use the special mandrel plateholder adjusting wrench No. 19056.

(3) Rotate the adjusting wheel until the clearance between the skiving brush and mandrel is such that the brush bristles will not contact the wire braid in the hose. Check the clearance by engaging the hose with the mandrel.

(4) Depress the START switch on the pushbutton control to start the motor.

(5) Engage the hose with the mandrel, and push toward the mandrel shoulder until the end of the hose is approximately even with the inner edge of the brush. The brush may or may not contact the hose, according to the previously made adjustment.

(6) Adjust the skiving depth by rotating the adjusting wheel to advance the hose into the brush until the outer covering is removed and the wire braid appears bright, but the wires are not disturbed. Leave the adjusting wheel as set, remove

the hose, and tighten the socket-head screws securing the mandrel holder bracket.

(7) Engage the hose with the mandrel, and feed it into the skiving brush to the mandrel shoulder while rotating the hose clockwise to give it complete skiving. If the length of skiving desired is equal to or less than one brush width, only one revolution of the hose will be enough. For longer skiving lengths, rotate the hose as many revolutions as necessary for complete skiving.

(8) Withdraw the hose from the mandrel, and depress the STOP RESET switch.

Exercises (272):

1. What is meant by skiving?
2. What is on either end of the electric drive motor?
3. What happens if the electric motor exceeds full-load current?
4. What is the purpose of the oil-fog system?
5. Why should safety glasses or goggles be worn when operating the hose cut off or skiving sections?

6. What is the purpose of the hose pins on the cutting table?
7. How can you tell if a hose has been skived properly?
8. If the length of skiving desired is equal to or less than the brush width, approximately how many revolutions will be necessary to skive the hose?
9. What is the purpose of the cutting arc the hose is forced into by the cutting handle?
10. How is the cutting table released from the loaded (retracted) position?

273. Specify the inspection and maintenance procedures performed on the hose cutting and skiving machine.

Inspection. Visually inspect the base plate and housing for cracks and breaks. Repair or replace if they are cracked or broken.

Inspect the cutting section, skiving section, and motor for loose mounting, loose covers, and missing mounting hardware. Tighten loose mounting hardware and replace damaged or missing mounting hardware.

Inspect the belt for cracks or excessive wear. Replace if cracked or excessively worn.

Disconnect power, then manually rotate cutoff knife blade while inspecting the edge for excessive wear (dullness), nicks, and damage which would prevent smooth cuts. Check for end and side play. Run out of blade measured at the cutting edge should not exceed 0.010 total indicator reading. Sharpen a dull blade and dress out nicks; replace the blade if wear or damage cannot be corrected by sharpening. Replace the bearings if excessive end or side play is evident.

Check the skiving brush retainer nut for looseness, and tighten if loose. Inspect all visible wiring for broken, cracked, or deteriorated insulation. Repair insulation or replace wiring. Check the pushbutton control for loose mounting or damage. Tighten the loose mounting hardware. Repair or replace the damaged control. Check the air and coolant lines and fittings for leaks and damage. Tighten or replace leaking or damaged

fittings. Repair or replace leaking or damaged lines. Then, inspect the oil-fog lubricator bowl for cracks and breaks. Replace if cracked or broken.

CAUTION: The blade shall be inspected each 30 days, using any destructive inspection technique available at using activity.

Blade Sharpening. Dull blades can cause overheating and should be kept sharp. When it has been determined the blade needs to be sharpened, it should be removed and forwarded to the machine shop for sharpening. Sharpening the blade on the machine is not to be attempted due to the high rpm of the motor.

General Cleaning. Infrequent cleaning only is required of the cutting and skiving sections, since both are essentially self-scavenging. However, waste may build up in the guards and cause binding of the blade or brush and overheating of the blade. To clean the cutting section, remove the screws securing cutoff knife blade guard, and remove the guard. For cleaning the skiving section, disconnect the exhaust system, remove the screws securing the bursh guard cover, and remove the cover. Brush or scrape out accumulated waste using care to avoid damage to the blade or to avoid disturbing the skiving bursh bristles. Replace the covers, and secure with screws. Connect exhaust system to the skiving section. Daily or whenever accumulation becomes excessive, clean the waste material from the finished surface of the mandrel holder bracket ways, adjusting screw threads, base plate, and other areas where the waste has collected.

Lubrication. The cutting blade shaft and motor are equipped with sealed bearings and do not require lubrication. Apply lubricating oil, general-purpose, low-temperature, Military Specification MIL-L-7870, every two weeks to the cutting table pivot points, also, to the cutting handle ratchet pawl, mandrel plate pawl, and mandrel holder bracket ways and adjusting screw. Use the tip of the oil can spout to depress the seal on the cutting table oil fittings to apply the lubricant. Pull out the pawls to lubricate. Maintain a supply of SAE 10 weight motor oil or equivalent in the oil-fog lubricator bowl. Do not use lubricants containing graphite, soaps, or fillers.

Exercises (273):

1. If the cutoff blade needs to be sharpened, how would this be done?
2. How often does the cutoff blade need to be inspected for cracks?

3. Why should the power be disconnected when inspecting the blade for wear?
4. What should you do if the belt is cracked or shows signs of excessive wear?
5. What happens if the cutoff blade is dull?
6. What could happen if waste is allowed to build up in the guards of the blade or wire brush areas?
7. What type of lubrication should be used to lubricate cutting table pivot points?
8. What type of oil is maintained in the oil-fog lubricator bowl?

274. Describe in terms of size, speed, and position the construction of the hose assembly machine, and state operational characteristics of hose assemblies.

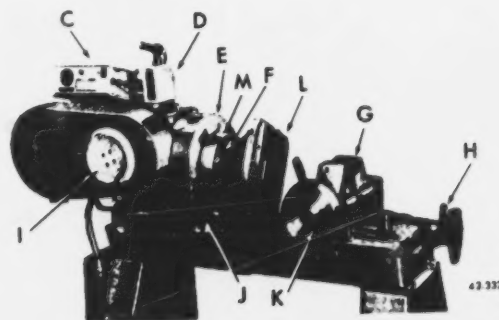
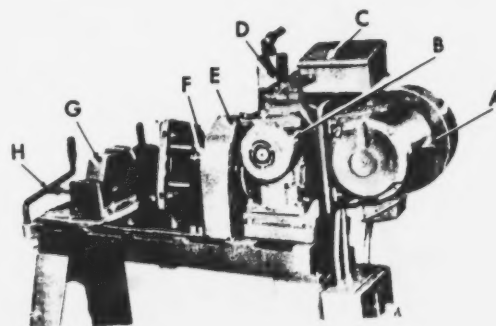
Hose Assembly Machine. The unit used in this section is shown in figure 6-7. It allows the mechanic to rapidly assemble or disassemble standard hose fittings. Once you have set up your machine, you can process hose assemblies rapidly and with little effort. Compare this to the hand method described earlier. The unit shown in figure 6-7 can accommodate medium-pressure hose fittings sizes 3 through 32. In the high-pressure hose fitting only sizes 4 through 16 can be used. With this unit you can also handle the flange, elbow, male pipe, and swivel-type fittings.

This machine is powered by a 1½-hp electric motor (A). The electrical requirements are 220/440 volts, 3-phase, 60-Hertz AC power. The motor drives a speed reducer by means of a V-belt. The three step sheaves to the speed reducer (B) provide for output speed of 40, 90, and 140 rpm. The belt can be moved from one size pulley to another to increase or decrease the speed. The machine is controlled by switch (D). This switch has three positions; forward, reverse, and off. There is a pushbutton switch on the handle for deenergizing the clutch.

Control box C, operating on 110 volts AC, controls the energizing and operation of the torque

limiting device. The torque limiter automatically senses predetermined torque values and allows the prescribed gap setting. The control switch on this box has three positions, RUN, OFF and JOG. A dial provides a means of selecting the proper cutoff torque. Brake M, operated by lever J, controls the rotation of the overriding head assembly F. Chuck L is also part of the head assembly and is used to hold fittings. Carriage and vise assembly G includes a vise for holding fittings and hose. The handwheel K opens and closes the vise. Operating lever H controls horizontal movement of the carriage. Transmission handwheel I provides for manual rotating alignment of the chuck. The clutch E transmits torque to the chuck when engaged.

The direct drive lever is a V-shape lever on the overriding head (not shown). It allows the chuck to



- A. Motor
- B. Speed reducer
- C. Control box, torque limiter
- D. Control switch
- E. Clutch
- F. Overriding head
- G. Carriage and vise assembly
- H. Lever, vise carriage
- I. Handwheel, transmission
- J. Handle, brake lever
- K. Handwheel, vise
- L. Chuck
- M. Brake

Figure 6-7. Hose assembly machine.

turn, or only the mandrel, depending on its position. The overriding head may be engaged two ways:

- By positioning the direct-drive lever on the head assembly.
- Energizing the clutch by placing switch on switch on control box (G) to either run or jog position.

Operating instructions for manufacturing a medium high pressure hose assembly. Before this machine is set up for operation, make sure that all electrical power is off. Then select the proper mandrel drive of the overriding head, being careful not to damage the threads. Next, insure that the chuck has the proper jaws installed. Position the mandrel until "B" nut is totally engaged in the jaws. Adjust the jaws to the fitting, providing clearance for the "B" nut of approximately 1/64 inch. Never use an extension on the chuck wrench since the excessive pressure may damage the chuck jaws.

Disengage the overriding head by positioning the direct-drive lever to DISENGAGE.

Place the brake lever handle to the DOWN position. Switch the machine control switch to forward and place the nipple and nut assembly on the mandrel. When the nipple and nut assembly bottom on the mandrel, the overriding head will start to turn. Once this happens, release the brake by placing the brake lever to the UP position. Place the hose and socket assembly in the carriage vise with the socket extending 1/4 to 1/2 inch. Tighten the jaws of the vise securely on the socket. Lubricate the nipple and hose bond freely.

Move the carriage vise forward until the nipple enters the hose bond and the nipple threads engage the socket. The overriding head is still rotating at this time in the FORWARD position. Allow the nipple to thread into the socket until a gap of 1/16 inch maximum exists. Do not allow the pieces to be tightened to the point that they contact each other. This would not give any freedom for "B" nut rotation during installation of hose.

When the proper clearance is reached, switch the machine to OFF. Apply the brake and switch the machine to REVERSE; the assembly should back off the mandrel. When the nipple assembly is clear of the mandrel, switch the machine to OFF. Now repeat the same process to the opposite end of the hose.

Operating instruction for manufacturing a high-pressure rubber hose assembly. Select the correct size, and type of mandrel for the size fitting and type hose to be assembled (high-pressure mandrels are different from medium-pressure hose mandrels), then thread the mandrel onto the mandrel driver stud in the overriding head. Next, install the correct size jaws in the chuck and adjust them to the fitting hex, providing a slip clearance of approximately 1/64 inch. In order to place the socket onto the

high-pressure hose, strip the hose of its outer cover (this was covered earlier when we talked about the hose cutting and skiving machine); then, apply sufficient adhesive specification MMM-A-1617, Type II, to the stripped portion of the hose so when the socket is installed, the adhesive completely fill the gap between the socket and hose. Next, install the socket on the hose by screwing it counterclockwise until it bottoms, then back it out 1/4 turn. Now load the hose and socket in the carriage vise with the socket protruding 1/8 to 1/4 inch from the vise. Lubricate the socket threads, hose bore, nipple, and mandrel with SAE 30 oil or petrolatum. Set the dial on control box 80-90, and place the control switch to RUN position. Now move the switch control handle to the FORWARD position. This will cause the overriding head and chuck assembly to rotate. Next, move the carriage vise until the nipple and socket threads engage. Once they are engaged, release the pressure of the carriage handle. Let the overriding head and chuck screw the nipple hex into the socket until the correct gap (1/16 inch maximum) is attained between the socket and nipple hex. Once the proper gap is attained, push the declutching button located on the control switch handle (this causes the overriding head and chuck assembly to stop rotating). Now move the handle to the OFF position. (NOTE: The declutching button is operational only when the clutch control box switch is in RUN position. The JOG position of the clutch control box switch just produces maximum torque.) Pull the carriage away from the overriding head and chuck assembly, and remove the hose from the vise. Now repeat the same process to the opposite end of the hose.

For all types of machines, consult the proper TO for further instruction. TO insure proper operation and safety, be sure to read the TO before using this hose assembly machine.

Maintenance. Check the oil level in the speed reducer. Proper oil level is approximately 1/2 inch below the flat part of the dip stick. Replenish, if necessary, using SAE 90 oil. Lubricate the chuck (two fittings) and all other fittings, using grease MIL-G-3545 or equivalent. Check the operation of the chuck. If operation is not smooth, check for dirt or other foreign matter on the cam block or screws. If dirt or foreign matter is found, clean with drycleaning solvent. Dry the parts and lubricate as instructed previously.

Exercises (274):

1. What size hose (medium-or high-pressure rubber) can the hose assembly machine make?

2. What are the three speeds of the hose assembly machine?
3. What are the three positions of the control switch?
4. How is the overriding head engaged?
5. What position is the overriding head in when manufacturing a medium-pressure hose assembly?
6. When making a medium-pressure rubber hose assembly, how far should the socket extend from the carriage vise?
7. Why should you have 1/16 cap between the nut and socket of a medium-pressure hose assembly?
8. What should you do after attaining the correct gap on a medium-pressure rubber hose to unscrew the mandrel from the hose fitting?
9. You are manufacturing a high-pressure hose assembly and are going to use the declutching button on top of the control switch handle, which position should the clutch control box switch be placed?
10. What is the job position of the clutch control box for?
11. What can be done to slow the speed of the hose manufacturing machine?
12. What does the direct drive lever do?

6-3. Ultrasonic Filter Cleaning

Sound is vibration energy. Vibrations at a frequency of 16 to 15,000 cycles per second can be heard by the human ear. Vibrations above this level are termed ultrasonic. One of the first practical uses of ultrasonics was a sonar device. This was developed during World War I for detection of submarines.

As research continued, it was found that ultrasonic energy could be used for mixing "unmixable" liquids, destroying bacteria, acceleration of chemical reactions, cleaning intricate mechanisms, and many other uses. This is where we come into the picture. We use ultrasonics for cleaning intricate mechanisms such as filters.

Ultrasonic cleaners are designed for many different applications. They range in size from a small tabletop unit up to 500-gallon cleaners, or possible larger. They can be used for cleaning filters, electronic parts, and small or large mechanical units. Possible you have taken your wristwatch to a jeweler for cleaning; many jewelers use ultrasonic cleaners to clean watches.

275. Name the basic components in a sonic system, then specify how sonic energy performs its cleaning functions.

The Sonic System. A sonic system is composed of two basic parts, a generator and a transducer. The generator may be either electronic or rotary. The transducer converts electrical energy into mechanical energy in the form of vibrations. The transducer is the heart of the sonic system, so we will cover it in more detail.

Transducers fall into two classes—piezoelectric and magnetostrictive. A piezoelectric transducer is composed of a natural crystal such as quartz. Or, it can be a special ceramic. While under the influence of an electrical voltage they both emit sonic vibrations. The magnetostrictive transducer is composed of a metal such as cobalt, nickel, or iron. A magnetostrictive metal is one that undergoes size change when subjected to a magnetic field. When the magnetic field is relieved, the metal returns to its natural dimensions. In a magnetostrictive sonic system, the transducer can then be vibrated by an interrupted or alternating magnetic field.

The choice of a transducer depends upon the sonic energy application needed. Generally speaking, the crystal or ceramic transducers are used for low power applications. The used for low power applications. The magnetostrictive transducer is used where power is to be applied for longer periods of time without loss in efficiency.

Sonic Energy Cleaning. Ultrasonic cleaning accomplishes its purpose in two ways. One, the cavitation of the liquid is physical. The other is

chemical—the solution dissolving the soluble soilage. For this we use a tank filled with a cleaning solution. The type of solution depends on the type of soils to be dissolved. We attach a transducer to the bottom of the tank to produce vibrations that are transmitted throughout the cleaning solution and cause the cavitation effect.

Cavitation is the formation of billions of microscopic sized cavities within a liquid. These cavities are filled with vaporized solution when the pressure on the liquid is reduced below the vapor pressure point of the liquid. Under this condition the vapor bubbles or cavities appear throughout the liquid in a flash.

How is this low pressure created? When sound waves are transmitted through air, there are alternating zones of high pressure and low pressure. the air molecules are squeezed together during the high-pressure front of the wave, but they are spread apart during the low-pressure part. When sound waves pass through a liquid, it is almost impossible to squeeze the liquid molecules together, but a low-pressure area follows the high-pressure front. Now, the low vapor pressure (the tendency of all liquids to vaporize in a vacuum) will cause the liquid molecules to separate from each other. At this point they are no longer a liquid but enter the gaseous state. This forms billions of vapor cavities in the low-pressure front of the sound wave. Now comes the high-pressure front of the next wave. It pressurizes all the vapor in the cavities, compresses the vapor-liquid mixture. It collapses all the cavities by compressing the vapor back into a liquid. Collapse of these cavities is called implosion.

While the energy in any one implosion is extremely small, there is an uncountable number of them. It is calculated that enormous pressures (in the order of 10,000 pounds per square inch) and enormous temperatures (of approximately 20,000° F) are developed. The formation and bursting of these vapor pockets with their fantastic pressures and temperatures does the scrubbing. This action takes place millions of times per minute. It can be described as "millions of tiny scrubbing fingers at work." The sound waves are simply the mechanical means to achieve cavitation.

Dissolved air and other gases play a role in ultrasonic cleaning. Some of the sound wave energy is absorbed by the cushioning effect of the air bubbles in the solvent. Fortunately, the sound waves cause the air bubbles to coalesce (join together) and float to the surface where they escape. Ultrasonic agitation will outgas (cause gas to leave) liquids within a period of 30 seconds to a few minutes. During this time the trapped air bubbles act as an energy sink. Cleaning will not be very effective until the liquid is completely degassed.

Exercises (275):

1. What two basic parts are needed for a sonic system?
2. Which transducer is used for long periods of time without loss of efficiency?
3. Which two ways does the ultrasonic cleaner accomplish its job?
4. What does the transducer do?
5. Define cavitation.
6. What causes the implosion in the cleaning solution?
7. What does the scrubbing in the ultrasonic cleaner?
8. Cleaning will not be effective until the cleaning solution is degassed. Explain what this means.

276. List the five tanks of the SANE 50 ultrasonic cleaner and specify tank purpose and the procedures for cleaning and testing a filter element.

PD SANE 50 Ultrasonic Cleaner. The SANE 50 is a typical machine for discussion of specific ultrasonic cleaners. This cleaning machine rapidly cleans and tests woven wire filter elements. Cleaning solutions used with this machine are carbon remover, Fed. Spec. P-C-111A, and the trichloroethylene, Fed. Spec. 0-T-634A.

Some geographic areas now prohibit or restrict the use of trichloroethylene for use in vapor degreasing. When local laws or regulators prohibit the use of trichloroethylene, refer to 34Y2-73-1 for approved substitutes.

These solutions should be handled carefully to avoid breathing the vapors, and to prevent contact with exposed skin areas. Protective clothing

including eyeshields, rubber safety-toe shoes, plastic-covered aprons, and rubber-impregnated gloves will be worn by personnel working with these solutions.

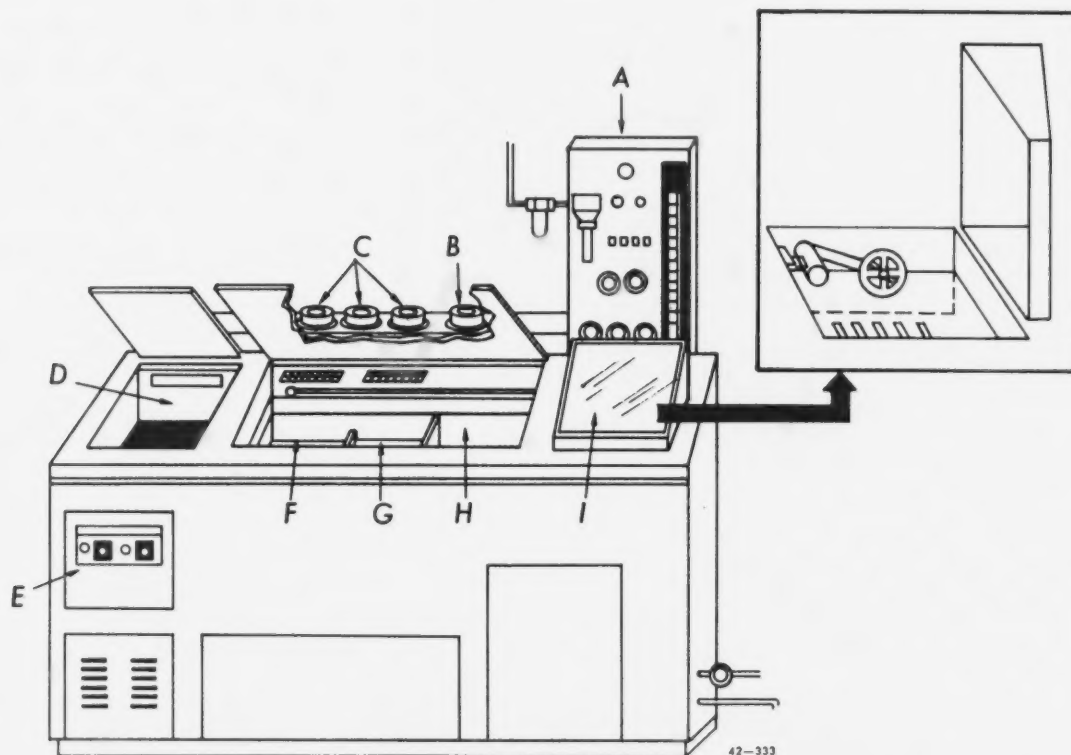
The SANE 50 ultrasonic cleaner is shown in figure 6-8. It consists primarily of five tanks. The tanks are presoak (D), boil (F), cleaning (G), condensate (H), and test tank (I). Each of these tanks serves a separate function in the cleaning process.

Presoak tank. The presoak tank (D) is filled with carbon remover. It has a cooling coil, heater, thermostat, drain pump, and sonic unit. This tank is used for loosening the dirt in the filter elements.

Boil tank. The boil tank (F) is filled with trichloroethylene and is provided with a heater and thermostat. The filters being cleaned bypass the boil tank. They go from the presoak tank directly to the cleaning tank. The boil tank heats and vaporizes the dirty trichloroethylene for recovery in the condenser.

Cleaning tank. The cleaning tank (G) is also filled with trichloroethylene. This tank is provided with a cooling coil, thermostat, sonic unit, three filters (C) (50-, 10-, and 3-micron), pump, and drain valve. The cleaning tank provides ultrasonic agitation and circulation of the cleaning fluid. This further removes dirt particles from the filters being cleaned. The circulation passes the dirt on to the filters within the stand.

Condensate tank. The condensate tank (H) is kept full of trichloroethylene by the normal boil-condense cycle of the unit. This is done by the use of a condensing coil, collecting trough, and water separator. The condensing coil prevents vapors from rising above a safe level in the center bay. The trough, located just below the condensing coil, is slanted toward the water separator. The condensed liquid flows down the trough to the water separator. Trichloroethylene, being heavier than water, settles to the bottom and goes into the condensate tank. Water rises to the top of the



- A. Control and test tank
- B. Test tank filter
- C. Cleaning tank filters (3)
- D. Presoak tank
- E. Sonic control panel (presoak and cleaning tanks)

- F. Boil tank
- G. Cleaning tank
- H. Condensate tank
- I. Test tank

Figure 6-8. Ultrasonic filter cleaner.

separator and is drained overboard. The condensate tank stores trichloroethylene for servicing the test tank.

Test tank. The test tank (I) is used to test cleaned filter elements for internal damage. The tank is filled with trichloroethylene from the condensate tank. It has a 3-micron filter (B) and pump for servicing and cleaning the test fluid. A cooling coil, heater, and thermostat switch control the test temperature. The test tank has a fixture for mounting and supplying air pressure to the element being tested.

Cleaning operation. Before cleaning, the filter elements are inspected for obvious damage beyond economical repair. Total repair may not exceed 3 percent of the filter element's total wire cloth area. Remove the O-ring seals from the elements selected for cleaning.

To start the cleaning process, suspend the elements in the presoak tank (D). This tank is filled with carbon remover. With the temperature at 100° F, ultrasonically agitate the elements for 15 minutes. Remove the elements and wash them with warm water to remove carbon remover and allow to drain.

After draining, suspend the elements in the ultrasonic cleaning tank (G). The cleaning tank is filled with trichloroethylene at a temperature of 140° to 150° F. Ultrasonically agitate for 10 to 30 minutes. A longer period of time is required when six or more elements are cleaned at the same time.

While the elements are in the cleaning tank, recirculate the cleaning fluid through the filters (C) for 5 minutes. Then, again agitate the elements for 3 minutes. Immediately take a 300-milliliter (½-cut) sample of the cleaning fluid. Filter this sample through a 5.0-micron membrane filter patch. Visually inspect the filter patch for solid particles or discoloration from solids. Elements that are not clean (as indicated by the dirty filter patch) must be reprocessed until cleanliness is assured.

All cleaned filter elements must be tested for serviceability. This is done in the test tank (I). The element is attached to the test fixture and air pressure is applied inside the element. The fluid level (trichloroethylene) should be ½ inch above the element for this test. Apply the specified air pressure as measured on the manometer and rotate the element. Air should escape through the pores of the element at a uniform rate over the entire surface. During this process a specified back pressure must be indicated on the manometer. Minimum back pressures to be maintained in the manometer while air is escaping through the filter are:

20 in. of H₂O for a 15-micron absolute element.
12 in. of H₂O for a 25-micron absolute element.
7.5 in. of H₂O for a 40-micron absolute element.
(The absolute rating indicates nothing larger will pass through it.)

Failure to maintain these back pressures indicates enlarged pores or a ruptured element. In this case the filter is condemned if the damaged area exceeds 3 percent of the total surface area. It may be repaired if the damage is less than 3 percent.

A large amount or a steady stream of bubbles coming from one spot on the element points up a fault. This is an indication of high porosity or a rupture at that point. If this occurs and the element fails the minimum back pressure test, reduce the air pressure to zero. Then gradually increase the pressure until the first continuous stream of bubbles occurs. If this bubble point falls between 3 in. of H₂O and the minimum allowed, the element is repairable. Elements testing less than 3 in. of H₂O are condemned. The point on the wire cloth needing repair must be marked with a red pencil during the bubble test.

Use caution to prevent the filtering surface from being contaminated by handling. After testing, package the dry serviceable elements in individual clean plastic bags.

Maintenance. TO 34Y2-73-1 says that the RF shields (located just under the sonics control panel) should be inspected and cleaned at least every 10 days of operation. The strainers in the transfer drain and recirculating lines of the tanks should be inspected and cleaned at 90-day intervals. The filters built into the cleaner should be replaced or cleaned any time the filter buttons pop. If the filter buttons pop, this indicates that the filters are dirty. Every now and then the cleaning solutions will have to be replenished due to evaporation of the solutions. The tanks will have to be serviced as specified earlier. Other than these routine maintenance tasks, the machine should last many years without causing any maintenance problems. If problems do arise, the TO has a troubleshooting chart that will help you determine the malfunction.

Exercises (276):

1. Name the five tanks of the SANE 50.
2. Which tank is used to vaporize the trichloroethylene?
3. Describe the purpose of the presoak tank.
4. Which tanks provide sonics agitation?

5. How is the condensate tank serviced with trichloroethylene?
6. Where does the trichloroethylene come from to service the test tank?
7. Which tank is the sample of fluid taken from when performing the patch test?
8. How high should the fluid level be above the filter being tested in the test tank?
9. How is the pressure measured when testing a clean filter in the test tank?
10. If a larger amount of air comes from one spot on a filter assembly being tested, what would this indicate?
11. In what should clean filters be placed after being cleaned and tested?
12. If the filters buttons built into the machine pop up, what does this indicate?
13. What should be done after the filter has been cleaned in the presoak tank?
14. After performing the patch test, what should be done if the patch is clean?

Answers for Exercises

CHAPTER 1

Reference:

- 200 - 1. Boyle's law is stated "The volume of an enclosed dry gas varies inversely with its pressure, provided the temperature remains constant."
- 200 - 2. Charles's law says "All gases expand and contract in direct proportion to the change in temperature, provided the pressure remains constant."
- 200 - 3. Pascal's law applies only to confined fluids. His law states "When a force is exerted on a confined fluid, the pressure is transmitted equally and undiminished in all directions."
- 200 - 4. Pascal's law does not apply to fluid in motion.
- 201 - 1. 3.14 square inches.
- 201 - 2. 141.30 square inches.
- 201 - 3. a. 1200 lbs.
b. 10 sq in.
c. 50 psi.
- 201 - 4. a. 5 cu in.
b. 5 inches.
c. 5 sq inches.
- 201 - 5.
- | A | B |
|--------------|--------------|
| V = 20 cu in | V = 20 cu in |
| A = 5 sq in | A = 5 sq in |
| L = 4 in | L = 2 in |
- 201 - 6.
- | A | B |
|-------------|--------------|
| F = 800 lbs | F = 1600 lbs |
| A = 2 sq in | A = 4 sq in |
| P = 400 psi | P = 400 psi |
- 202 - 1. 24.
- 202 - 2. 3.
- 202 - 3. 15.

- 203 - 1. T.
- 203 - 2. F. Cross out *non* and *whirling*.
- 203 - 3. T.
- 203 - 4. F. Turbulence in the fluid will increase.
- 203 - 5. T.
- 203 - 6. T.
- 203 - 7. F. Take out *turbulent* and add *laminar*.
- 204 - 1. 100 ft-lbs.
- 204 - 2. Potential.
- 204 - 3. Kinetic.
- 204 - 4. Heat energy.
- 204 - 5. 100 ft-lbs.
- 204 - 6. Kinetic.
- 204 - 7. Potential.
- 205 - 1. 15.55 (15.6) centigrade.
- 205 - 2. 39. 2 Fahrenheit.
- 205 - 3. Approximately 1.8 meters.
- 205 - 4. Approximately 7.6 centimeters.
- 205 - 5. 2 gallons.
- 206 - 1. T.
- 206 - 2. T.
- 206 - 3. T.
- 206 - 4. T.
- 206 - 5. F. Delete *electrons* and add *protons*.
- 206 - 6. F. Protons are positive and electrons are negative.
- 206 - 7. T.
- 206 - 8. F. It has less electrons.
- 206 - 9. T.
- 206 - 10. T.
- 207 - 1.

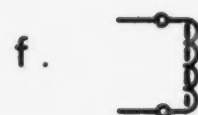
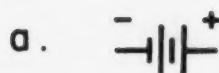


Figure 1. Answer for objective 207, exercise 1.

- 207 - 2. a. T.
b. T.
c. T.
d. F. An ammeter is used to measure current.
e. The unit of measurement for electrical pressure is the volt.
f. T.

- 208 - 1. 10 amperes.
208 - 2. 12 volts.
208 - 3. Decreased; decreased.

- 209 - 1. $E_1 = 28$ volts, $I_1 = 3$ amps, $R_1 = 7$ ohms
 $I_1 = 4$ amps, $E_2 = 24$ volts, $I_2 = 4$ amps

- 210 - 1. $R_1 = 2$ ohms.
210 - 2. Total circuit resistance would decrease.
210 - 3. More than one.
210 - 4. Voltage.

- 211 - 1. A series-parallel circuit could be defined as a circuit combining a series circuit and a parallel circuit into one circuit.
211 - 2. $R_1 = 40$ ohms.
211 - 3. $I_1 = 2$ amps.

- 212 - 1. All magnetic substances are composed of tiny magnets that exhibit all the properties of magnets.
212 - 2. The lines of force on the outside of a magnet.
212 - 3. a.
212 - 4. North; south.
212 - 5. An electromagnet is merely a piece of iron with wire wrapped around it. When electrical power is applied a magnetic field is created.

- 213 - 1. When the coil of wire is energized it creates an electromagnet. When this happens the spool is pulled toward the center of the coil of wire. This opens the passageway for fluid to flow.
213 - 2. The magnetic field is used to open or close the contact points.
213 - 3. By the repelling and attraction of the coil that is placed between the fixed magnets. This interaction of the magnetic fields causes the coil (armature) to rotate.
213 - 4. The commutator segments.

CHAPTER 2

- 214 - 1. Noncorrosive, good lubricating qualities, high flash-point, low toxicity, and ability to flow freely at extreme low temperatures.
214 - 2. For identification purposes only.
214 - 3. It is primarily used as a preservative, but can be used for testing or flushing some hydraulic components.
214 - 4. Because of its fire resistant qualities.
214 - 5. Mil-H-5606.
214 - 6. When a product has been classified as being standardized between two or more countries.
- 215 - 1. Headache, dizziness, vomiting, sleepiness, and dermatitis.
215 - 2. Solvents are used to dissolve other substances.
215 - 3. Trichloroethylene.
215 - 4. Dizziness, loss of appetite, sleepiness, headache, fatigue, vomiting, and dermatitis.
215 - 5. Above 105° F.
215 - 6. To remove nicks, dents, scratches, or any other imperfections.
215 - 7. Aluminum oxide paper (300 grit or finer).
215 - 8. It could cause serious corrosion.

- 216 - 1. T.
 216 - 2. F. It provides a seal between moving parts.
 216 - 3. T.
 216 - 4. F. The number 28775 indicates the type of seal.
 216 - 5. F. You should also check for cuts, nicks, and/or flaws.
 216 - 6. F. Each seal will have its own cure date expiration.
 216 - 7. F. It is -65° to 275° F.
 216 - 8. T.
- 217 - 1. MS28775-115.
 217 - 2. 1Q75.
 217 - 3. 1Q80.
 217 - 4. Packing preformed O-ring.
- 218 - 1. Probably the seal was allowed to run dry, thus causing the seal to roll and/or cut.
 218 - 2. Hydraulic fluid.
 218 - 3. Because this may be the only lubrication for several years.
 218 - 4. MIL-G-4343.
 218 - 5. The seal running dry, causing friction between seal and metal parts.
- 219 - 1. In most cases a backup ring will not be used when systems are below 1500 psi.
 219 - 2. Yes. The backup should be placed in back of the seal away from the pressure.
 219 - 3. No. The scarf edges of a backup should be staggered.
 219 - 4. The hair (smooth) side should be placed against the seal away from the direction of the pressure.
- 220 - 1. No, only if it is in excess of TO specifications. Slight leakage is normal.
 220 - 2. It compensates for the wear of the sealing ring by keeping the sealing ring in contact with the mating ring.
 220 - 3. Sealing ring and mating ring.
 220 - 4. Soft material such as bronze or carbon.
 220 - 5. Mating ring.
- 221 - 1. T.
 221 - 2. T.
 221 - 3. T.
 221 - 4. F. It should read high pressure instead of high temperature.
 221 - 5. F. Steel tubing does not need to be double flared.
 221 - 6. T.
 221 - 7. T.
 221 - 8. F. Two flats or 1/3 turn is the maximum a flareless tube should be tightened.
 221 - 9. T.
 221 - 10. F. This indicates that the flare is too large.
- 222 - 1. No.
 222 - 2. No, but the nick should be smoothed out.
 222 - 3. Yes. The tube assembly should be removed and replaced.
- 223 - 1. Type hose, size, date of manufacture, and manufacture's code.
 223 - 2. This is medium-pressure Teflon bulk hose, size 10, rated at 1500 psi, and manufacture's code.
 223 - 3. Size 10 hose.
 223 - 4. 4 years.
 223 - 5. It should be stored in a straight position in a dark, cool, dry place.
- 224 - 1. Flexibility.
 224 - 2. Socket and nipple.
 224 - 3. By hose cutting machine or fine-toothed hacksaw.
 224 - 4. By measuring the hose against the notch on the hose socket.
 224 - 5. To the wire braid.
- 224 - 6. It will tend to grind away the material inside the socket.
 224 - 7. Vice, hacksaw or hose cutoff machine, masking tape, and wrenches.
 224 - 8. Wrap masking tape around area to be cut.
 224 - 9. Between the inner tube and wire braid.
 224 - 10. 1/32 of an inch.
- 225 - 1. Any type of hydraulic testing unit capable of building pressure to the recommended values.
 225 - 2. As a safety measure.
 225 - 3. 5 minutes.
 225 - 4. The hose should be rejected.
 225 - 5. It should be flushed, capped, and properly etched.
 225 - 6. The installation date of a hose.
 225 - 7. The assembled date which includes the quarter and year plus the code for the base that manufactured the hose.
 225 - 8. It is made from high-pressure bulk hose, size 8, and is 15 1/4 inches long.
- 226 - 1. a. Within limits.
 b. Hose is bad—must be replaced.
 c. Hose is bad—four broken wires on a single plait.
 d. Hose is bad—six broken wires per assembly.
 226 - 2. a. Hose is installed improperly—it is stretched too much.
 b. Hose is installed improperly—it is twisted.
 c. Hose is installed improperly—the hose is kinked.
 d. Hose is installed properly with enough slack.
- 227 - 1. To make it easier to identify its contents.
 227 - 2. This symbol insures that people who cannot speak English, plus people who are color blind, can determine the contents of the line.
 227 - 3. Two tapes, one on each side of the bulkhead.
- 228 - 1. So a seal can be placed there.
 228 - 2. Blue.
 228 - 3. Type of fitting, material it is made from, and size.
 228 - 4. For high-pressure systems, that are subjected to severe vibration.
 228 - 5. Straight (machined).
 228 - 6. MS fittings.
- 229 - 1. Antiseize material was not used.
 229 - 2. Antiseize material was applied improperly during installation.
 229 - 3. The jamnut or universal fitting is stripped, due to improper position of jamnut.
 229 - 4. If the fitting is good, then you may have cut the seal as you were installing it on the fitting.
- 230 - 1. Bolthead markings identify the type of bolt and material it is made from.
 230 - 2. The grip length should be equal to the thickness of the material being joined.
 230 - 3. The hexhead bolt is used where heavy tension or lengthwise stresses may be encountered.
 230 - 4. Eyebolt.
 230 - 5. Cotter pins should fit the holes snugly and they should never be reused.
 230 - 6. Non-self-locking devices.
 230 - 7. At least two threads.
 230 - 8. The correct locking should fill its groove but can be rotated easily.
- 231 - 1. Double-twist, single-twist, and shear wire methods.
 231 - 2. It should be bent back or under to prevent it from injuring personnel.
 231 - 3. It is used on close geometrical patterns, as well as in places difficult to reach.

- 231 - 4. As many that can be secured with a 24-inch length of wire.
- 231 - 5. 0.020-inch-diameter steel safety wire.
- 232 - 1. The cable's diameter.
- 232 - 2. Seven; wires per strand.
- 232 - 3. Passing a cloth along the length of the cable.
- 232 - 4. It is used to adjust the tension on cables.
- 232 - 5. By a groove or knurl on the end of the barrel.
- 232 - 6. Three threads.
- 232 - 7. Four complete wraps.
- 233 - 1. Write them up as missing or broken, and if possible, replace them.
- 233 - 2. They are used to support tubing and hose subject to vibration.
- 233 - 3. The rubber clamp gives excellent cushioning against vibration, but can be torn easily and is not compatible with certain fluids.
- 233 - 4. The hose would not be supported properly.

CHAPTER 3

- 234 - 1. a. Common hammers.
b. Soft hammers (mallets).
c. Sledges.
- 234 - 2. a. (2).
b. (1) or (2).
c. (1).
- 235 - 1. To tighten or loosen screws.
- 235 - 2. The blade should fit snugly into the screw slot.
- 235 - 3. Use light pressure to prevent the metal from overheating which removes its temper.
- 235 - 4. Offset screwdriver.
- 235 - 5. Cross-point screwdriver.
- 236 - 1. To hold, grip, cut, or bend material.
- 236 - 2. Vise grips.
- 236 - 3. a. (2).
b. (4).
c. (1).
d. (5).
e. (3).
f. (1).
g. (6, 5).
h. (1).
i. (5, 6).
- 237 - 1. No.
- 237 - 2. Pushing is dangerous, because when the item you are working on gives way you could bust your knuckles.
- 237 - 3. Adjustable jaw wrench.
- 237 - 4. a. No.
b. Yes.
c. No.
d. No.
e. Yes.
f. Yes.
g. No.
h. Yes.
i. No.
j. No.
- 238 - 1. a. Blade with 24 teeth per inch.
b. Blade with 32 teeth per inch.
c. Blade with 32 teeth per inch.
d. Blade with 18 teeth per inch.
e. Blade with 24 teeth per inch.
- 238 - 2. a. T.
b. T.
- c. F. The hacksaw should be lifted off the work on the aft stroke.
- d. It should be decreased.
- 239 - 1. File card.
- 239 - 2. Double cut indicates that the ridges on the file are in two directions.
- 239 - 3. Use a course file for soft metals and a smooth file for hard metals.
- 239 - 4. For attachment of a handle.
- 239 - 5. a. Don't throw files in a toolbox where they can rub against other tools.
b. Don't apply too much pressure on new files.
c. Never file anything harder than the file itself.
- 240 - 1. Center punch.
- 240 - 2. Pin punch.
- 240 - 3. Drift or tapered punch.
- 240 - 4. Prick punch.
- 241 - 1. 64th of an inch.
- 241 - 2. Clearance between two surfaces.
- 241 - 3. Kinks; creases.
- 241 - 4. That experience will determine the accuracy of your readings.
- 241 - 5. a. +.
b. 0.
c. +.
d. 0.
e. +.
f. +.
- 242 - 1. To make accurate measurements.
- 242 - 2. The water manometer shows smaller difference than a mercury manometer.
- 242 - 3. Put the zero mark on the lower setting of mercury, then read the number of inches of mercury from the surface of the higher column.
- 242 - 4. High pressure (H.P.) side.
- 242 - 5. a. 5.
b. 5.
- 243 - 1. Out of round or end play on a shaft.
- 243 - 2. Place the dial indicator against the item to be measured. Loosen the lock screw and rotate the dial to zero.
- 243 - 3. It will indicate minus.
- 243 - 4. By adding the minus and plus readings, you obtain the total movement of the pointer.
- 244 - 1. It determines the size of cable.
- 244 - 2. Between two hardened steel blocks called anvils.
- 244 - 3. To clamp or release the cable during tension measurement.
- 244 - 4. By sliding point lock button to "On" before removing tensiometer from cable.
- 244 - 5. Counterclockwise to stop position.
- 244 - 6. A plunger forces the cable against the anvil.
- 244 - 7. By using the test bar.
- 244 - 8. The tensiometer is zeroed by rotating the indicator rim for cable size being measured.
- 245 - 1. Overtightening the micrometer against the item being measured.
- 245 - 2. If the item is not placed squarely between the anvil and spindle, you will not get an accurate measurement.
- 245 - 3. It could destroy the accuracy of the micrometer.
- 245 - 4. The vernier scale allows the micrometer to read in increments of ten-thousandths of an inch.
- 245 - 5. One revolution.
- 245 - 6. A. 0.342.
B. 0.393.
C. 0.871.

- 245 - 7. A. 0.4690.
B. 0.4697.

- 246 - 1. Breakaway torque wrench.
- 246 - 2. By turning the grip counterclockwise.
- 246 - 3. 60 days.
- 246 - 4. Lowest setting.
- 246 - 5. In foot-pounds or inch-pounds.
- 246 - 6. A color coded tape is attached to the torque wrench.
- 246 - 7. It should be rechecked for accuracy.

- 247 - 1. 80 inch-pounds.
- 247 - 2. 60 inch-pounds.
- 247 - 3. 25 foot-pounds.

- 248 - 1. T.
- 248 - 2. T.
- 248 - 3. F. More than likely it will be manufactured locally.
- 248 - 4. T.
- 248 - 5. T.
- 248 - 6. F. It can be made out of iron steel, but is usually made out of brass or aluminum.
- 248 - 7. T.

- 249 - 1. Precision measurement equipment laborator (PMEL).
- 249 - 2. Make sure that it is all there and in serviceable condition.
- 249 - 3. Verification is checking for accuracy, while calibration is the actual adjustment.
- 249 - 4. In the 33 category TOs.
- 249 - 5. AF Form 1297, Temporary Issue Receipt.
- 249 - 6. It will indicate if authorized personnel has tried to adjust equipment.
- 249 - 7. AFTO Form 27, User Certification Label.

CHAPTER 4

- 250 - 1. 20,000 ohms.
- 250 - 2. 150 milliamps.
- 250 - 3. To zero the ohms scale because of age or use of the battery.
- 250 - 4. In parallel or across the conductor.
- 250 - 5. 40 volts DC.
- 250 - 6. It could damage the meter.
- 250 - 7. 200 volts AC.
- 250 - 8. Red lead to positive and black lead to negative.
- 250 - 9. The FUNCTION switch would be set on D.C.V. 20k Ω /V or 1k Ω /V and the RANGE selector would be set on 50 volts.
- 250 - 10. The FUNCTION switch would be set on "ohms" and the RANGE selector would be set at $\Omega \times 100$.

- 251 - 1. When working in a noisy area.
- 251 - 2. Pointer zeroing eliminates indications of surrounding noises.
- 251 - 3. The sensing probe picks up the noise of a leak and converts it into an electrical signal.
- 251 - 4. When you are immediately over the leak.
- 251 - 5. It can indicate the general area of a leak, thus eliminating pulling unnecessary panels.

- 252 - 1. Wing and axle.
- 252 - 2. The reservoir and pump.
- 252 - 3. It prevents accidental lowering of the jack.
- 252 - 4. a. To prevent a vacuum from being formed as fluid is being withdrawn.
b. To prevent thermal expansion from building up when the jack is under a load.

- c. To prevent a buildup of pressure in the reservoir as the jack is being lowered.

- 252 - 5. Release the ram lock and open the needle valve.
- 252 - 6. The type of aircraft and job to be done.
- 252 - 7. So it will remain on top of the cylinder in case the ram should accidentally lower.

- 253 - 1. Parallel; perpendicular.
- 253 - 2. To make it easier to get the jack from beneath the aircraft.
- 253 - 3. To permit the use of one jack for a variety of aircraft.
- 253 - 4. MA-1 manifold cart.
- 253 - 5. One man on each jack plus a point man who stands out in front of the aircraft directing the jacking operation.

- 254 - 1. Base assembly, upper structure, and platform.
- 254 - 2. B-1, B-2, B-4, B-5, and C-1.
- 254 - 3. The upper structure of the B-2 maintenance stand is almost identical to the B-1 maintenance stand.
- 254 - 4. A U-shaped steel device which fits into grooves in cylinder assembly.
- 254 - 5. a. B-1—3-10 feet.
b. B-2—13-20 feet.
c. B-4—3-7 feet.
d. B-5—7-12 feet.
e. C-1—4 feet.
- 254 - 6. C-1.
- 254 - 7. To provide working platforms.
- 254 - 8. a. Reservoir.
b. Hand pump.
c. Cylinder.
d. Shutoff valve.
- 254 - 9. It should never be raised or lowered while standing on the ladder.
- 254 - 10. Crew chief.
- 254 - 11. It can be used independently or installed on the B-1 or B-2 stands.
- 254 - 12. For performing maintenance work or inspections on systems and components high above the ground.

- 255 - 1. To service the high-pressure air or nitrogen system of aircraft.
- 255 - 2. Cam lever valves.
- 255 - 3. Move the trailer closer to the aircraft.
- 255 - 4. Only one.
- 255 - 5. To indicate the pressure to the regulator and the amount of pressure leaving.
- 255 - 6. To bleed any trapped nitrogen pressure from the hose.
- 255 - 7. It should be blown out.
- 255 - 8. The one with the lowest pressure but higher than you need to service the aircraft.
- 255 - 9. Counterclockwise.
- 255 - 10. To eliminate moisture and foreign material from the nitrogen.

- 256 - 1. It will filter the fluid from the servicing cart.
- 256 - 2. Check valve.
- 256 - 3. In the hose storage compartment.
- 256 - 4. It will return to the reservoir.
- 256 - 5. Use the large volume pump.
- 256 - 6. To prevent dirt from entering the hose.

CHAPTER 5

- 257 - 1. To purge the air from the system prior to test stand operation.
- 257 - 2. 24-volt DC motor.
- 257 - 3. The filters are good.
- 257 - 4. Only system #2 will fill.
- 257 - 5. When the fill pump switch is placed to the ON position.
- 257 - 6. To check for leaks.
- 257 - 7. You must repeat the pressurizing and bleeding operation until a solid column of fluid can be seen in the sight tube.
- 257 - 8. No pressure will be developed and the system will not fill.

- 258 - 1. Sliding vane rotary pump.
- 258 - 2. Supply fluid to the main pump.
- 258 - 3. Test stand engine.
- 258 - 4. The thermal relief valve prevents the buildup of pressure due to expansion of the fluid after shutdown.
- 258 - 5. Pressure is regulated by the low-pressure relief valve.
- 258 - 6. From the stand reservoir.
- 258 - 7. If the temperature of the fluid rises to high.
- 258 - 8. The test stand will shut down.
- 258 - 8. It prevents the flow of low-pressure fluid back to the boost pump.
- 258 - 10. By visually observing the fluid passing through the sight tube.

- 259 - 1. The high-pressure system provides fluid at a controlled volume and pressure to the aircraft for ground testing and maintenance of the aircraft hydraulic system.
- 259 - 2. The high-pressure pump is a variable volume pump.
- 259 - 3. The pressure compensator automatically controls pump output and compensates for changes in pressure.
- 259 - 4. 3 gallons per minute.
- 259 - 5. The pump is lubricated by the fluid it pumps.
- 259 - 6. With the bypass through flowmeter valve open, the pump output is bypassed back to the boost pump. This results in no output pressure from the HP pump. The compensator cannot be adjusted unless the pump is capable of establishing an output pressure.
- 259 - 7. By pressure and return hoses.
- 259 - 8. The bypass valve must be closed and the flow control valve must be open.

- 260 - 1. He should immediately open the bypass through cooler valve.
- 260 - 2. When both valves are closed, there is a strong possibility that back pressure in the lines will rupture them, thereby endangering both the equipment and the operator.
- 260 - 3. As the fluid passes through the cooler, the heat is transferred to the cooling fins and is dissipated by air from the cooling fins.
- 260 - 4. The return line is low pressure which permits the use of a glass flowmeter. Since the hydraulic system is completely inclosed, the volume of fluid returning is equivalent to the volume being delivered.
- 260 - 5. The compressor is driven by a V-belt from the cooling fan shaft.
- 260 - 6. Pressurization reduces foaming in the reservoir.
- 260 - 7. The pilot unloader valve.

- 261 - 1. The maintenance forms.
- 261 - 2. The hoses and quick disconnects.
- 261 - 3. Three: engine oil, gear case oil, and air compressor oil.
- 261 - 4. The valves are checked for freedom of movement, looseness, and signs of leakage.
- 261 - 5.
 - a. Exterior of test stand.
 - b. Interior of test stand.
 - c. Instrument and control panel.
 - d. Hoses and quick disconnect.

- 262 - 1. Lines may rupture causing high-pressure fluid to be injected into eyes and skin.
- 262 - 2. The controls are identical but reversed in their location.
- 262 - 3. One behind each sight tube and flowmeter.
- 262 - 4. It must be in the external position.
- 262 - 5. The compensator will control pressure at its own setting. If it is not initially set above relief setting, the pressure will remain at the compensator setting.
- 262 - 6. It will engage the desired system pump to the test stands engine.
- 262 - 7. If the temperature of the fluid approached the red area on the gauge, the bypass valve should be opened. This will allow the fluid to pass through the cooler.
- 262 - 8. The test stand should be shut down at once.

- 263 - 1. It is an oil bath air cleaner.
- 263 - 2. The intercoolers and aftercooler remove the heat caused by compression of the air.
- 263 - 3. The separator, separates the moisture from the air.
- 263 - 4. The unloader valve assembly.
- 263 - 5.
 - a. When the compressor oil pressure decreased below 15 psi.
 - b. If air pressure exceeds the pressure switch setting.
 - c. If the normal drain switch is positioned to unload.
- 263 - 6. Because the pressure in each stage of compression is different.
- 263 - 7. The dehydrator absorb moisture in the compressed air which was not removed by the separators.
- 263 - 8. To the 10-micron filter.
- 263 - 9. The priority valve set at 2400 psig insures maximum effectiveness of the dehydrators.

- 264 - 1.
 - a. (6).
 - b. (5).
 - c. (4).
 - d. (3).
 - e. (2).
 - f. (1).
 - g. (5).

- 265 - 1.
 - a. 5.
 - b. 8.
 - c. 3.
 - d. 4.
 - e. 6.
 - f. 1.
 - g. 2.
 - h. 7.

- 266 - 1. The MD-3 is used to start aircraft and for performing operational checks of the system.
- 266 - 2. 28-volt DC and 115-200-volt, three-phase, 400-Hz AC electrical power.

- 266 - 3. Three 28-volt, 500-ampere DC generators and one 115-200-volt, 400-Hz, three-phase alternator.
- 266 - 4. Through a square plug cable.
- 266 - 5. The purpose of the split-bus system is to provide power for engine starting and at the same time furnishes power for operation of the aircraft instruments.
- 267 - 1. The choke should be used sparingly because the engine is easily flooded.
- 267 - 2. Make sure the RPM is correct and cylinder head oil temperature indicators are in the green range.
- 267 - 3. By a knob located on the front-wheel hub.
- 267 - 4. 5 mph with the drive mechanism engaged and 20 mph when being towed.
- 267 - 5. a. (4).
b. (1).
c. (2).
d. (2).
e. (3).
f. (6).
g. (3).
h. (7).
i. (5).
j. (6).
- 268 - 1. a. Noise.
b. Heat from exhaust.
c. High speed.
d. Electrical shock.
e. Bleed air hose.
f. Foreign object injection.
- 268 - 2. Place the master switch to the OFF position or close the fuel shutoff valve.
- 268 - 3. For battery charging and speed control.
- 268 - 4. The operating instructions and equipment design are subject to change, and the TO is supplemental to reflect the latest changes.
- 268 - 5. None. This is normal operation. If it is necessary to have both electrical and pneumatic loads, the electrical load must be reduced to a suitable level.
- 268 - 6. Stop the unit by placing the master switch to the Off position.
- 268 - 7. At approximately 95 percent of governed speed.
- 268 - 8. It is only necessary to reset the DC system if there was no DC buildup indicated on the DC voltmeter at 95 percent.

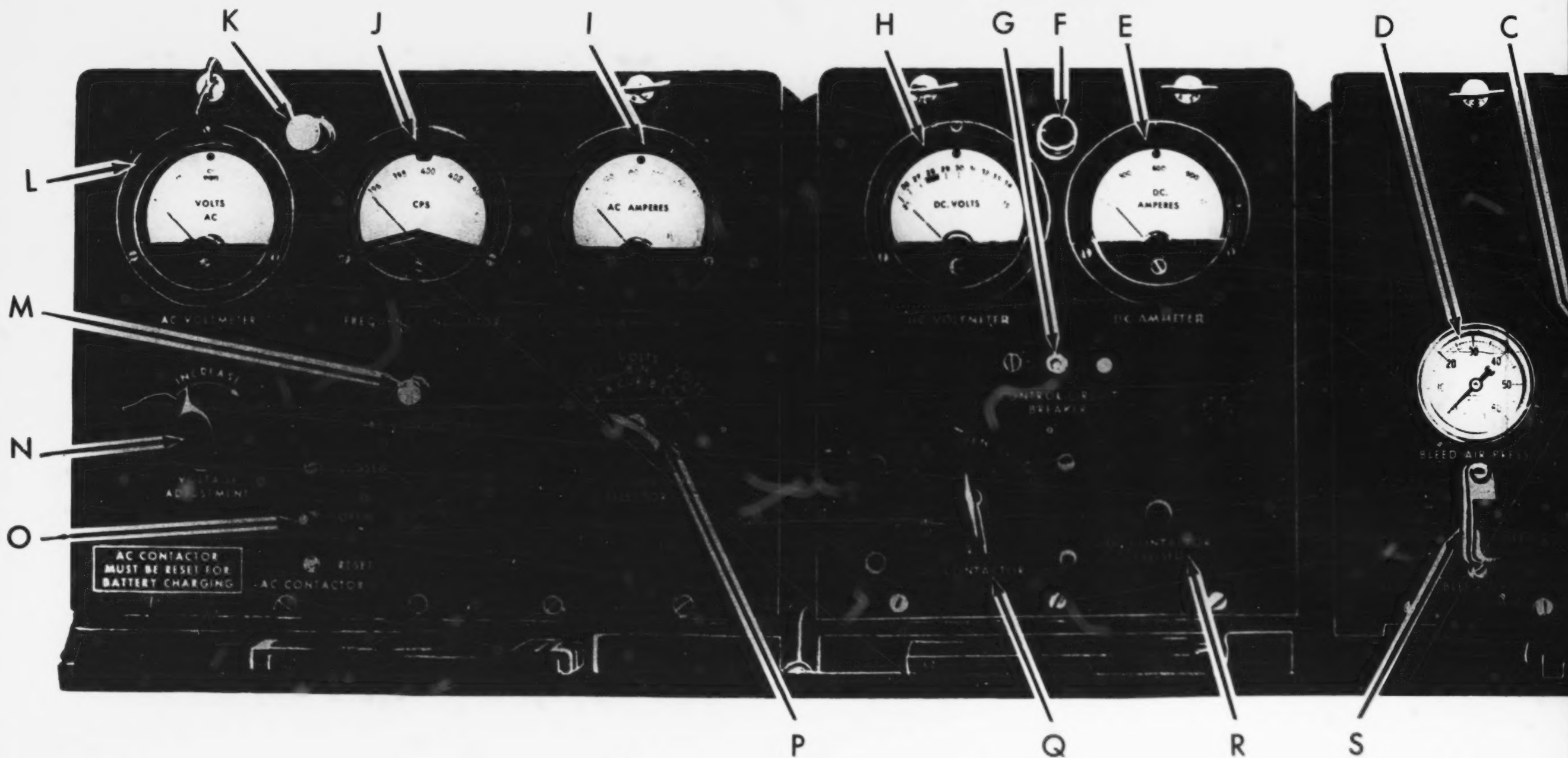
CHAPTER 6

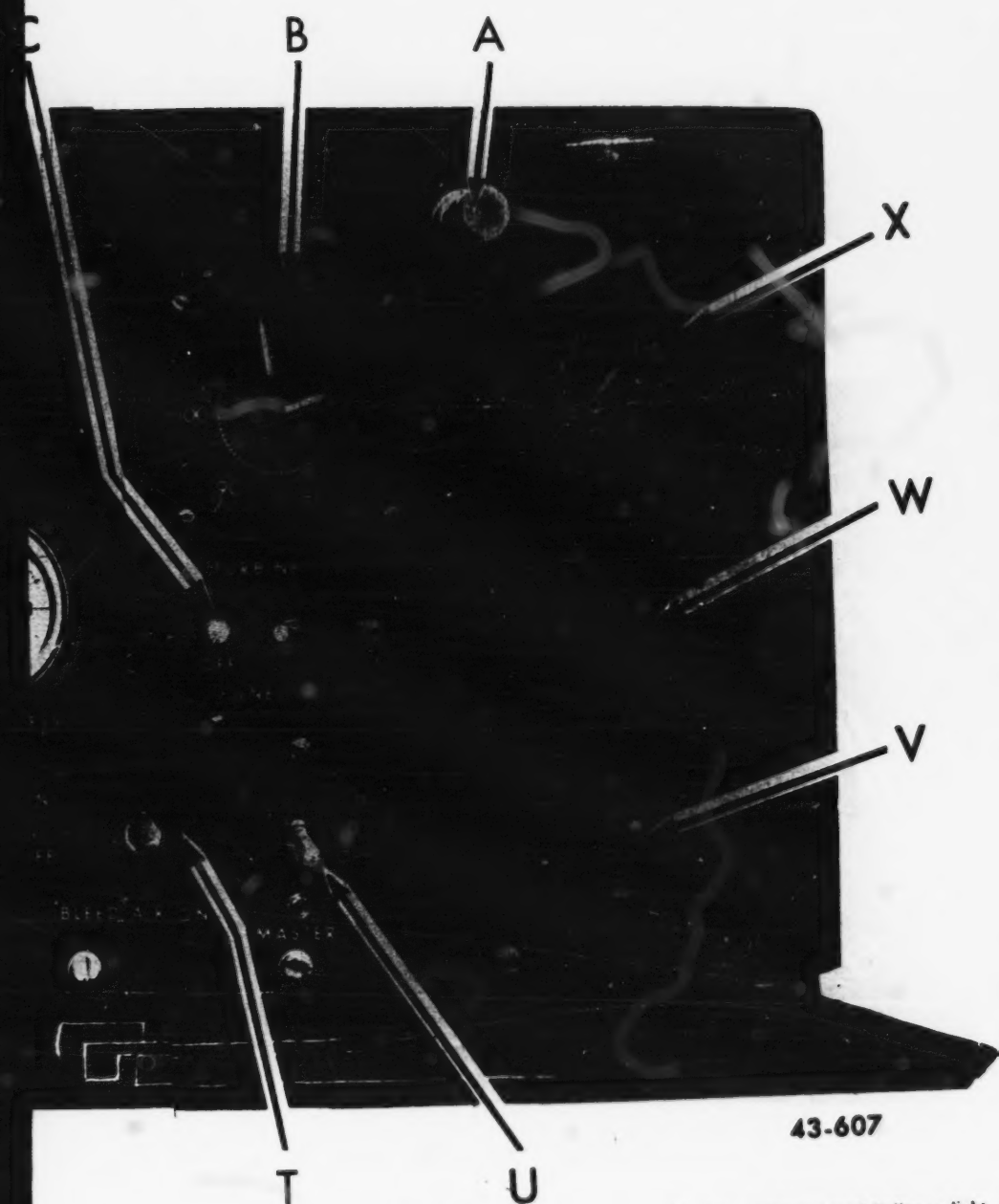
- 269 - 1. g.
- 269 - 2. d.
- 269 - 3. e.
- 269 - 4. i.
- 269 - 5. a.
- 269 - 6. d.
- 269 - 7. b.
- 269 - 8. e.
- 269 - 9. c.
- 269 - 10. f.
- 269 - 11. c.
- 270 - 1. T.
- 270 - 2. F.
- 270 - 3. T.
- 270 - 4. T.
- 270 - 5. T.
- 270 - 6. F.
- 270 - 7. T.
- 270 - 8. F.

- 270 - 9. F.
- 270 - 10. T.
- 271 - 1. The improper hose could burst.
- 271 - 2. It will allow the fluid from the high-pressure pump to flow through the larger flowmeter.
- 271 - 2. It will allow the fluid from the high-pressure pump to flow through the larger flowmeter.
- 271 - 3. To make sure all the lines are full of fluid.
- 271 - 4. The cylinder circuit shutoff (37) should be open and the selector (38) in the flowmeter return position.
- 271 - 5. Check the startup and operating procedures TO to make sure that all valves or switches are in the proper position.
- 271 - 6. Locking it in place.
- 271 - 7. a. Daily.
b. Semimonthly.
c. 4-month inspection.
d. Yearly.
- 272 - 1. Removing the outer covering from the high-pressure bulk hose.
- 272 - 2. Wire brush and cutting blade.
- 272 - 3. A thermal overload relay will interrupt power to the drive motor.
- 272 - 4. To cool and lubricate the cutting blade.
- 272 - 5. To protect your eyes from flying particles.
- 272 - 6. It forces the hose into the correct cutting arc.
- 272 - 7. When the outer covering is removed and the wire braid appears bright, but not disturbed.
- 272 - 8. Only one revolution.
- 272 - 9. It causes the cut surface to spread away from the blade to prevent binding and blade overheating.
- 272 - 10. By depressing the table latch.
- 273 - 1. It should be sent to the machine shop.
- 273 - 2. Each 30 days.
- 273 - 3. To prevent the motor from accidentally turning the blade.
- 273 - 4. Replace the belt.
- 273 - 5. It causes overheating of the blade.
- 273 - 6. It could cause binding and overheating of the blade.
- 273 - 7. Mil Spec Mil-L-7870.
- 273 - 8. SAE 10 weight motor oil or equivalent.
- 274 - 1. Medium-pressure hose sizes 3 through 32 and high-pressure hose sizes 4 through 16.
- 274 - 2. 40, 90, and 140 rpm.
- 274 - 3. RUN, OFF, and JOG.
- 274 - 4. By positioning the direct drive lever on the head assembly or by energizing the clutch.
- 274 - 5. Disengaged position.
- 274 - 6. 1/8 to 1/4 inch.
- 274 - 7. This allows the "B" nut to rotate during installation of the hose.
- 274 - 8. Apply the brake and switch the machine to REVERSE.
- 274 - 9. RUN position.
- 274 - 10. It produces maximum torque.
- 274 - 11. The drive belt can be moved from one size pulley to another.
- 274 - 12. It allows the chuck to turn, or only the mandrel, depending on the position in which it is placed.
- 275 - 1. Transducer and generator.
- 275 - 2. Magnetostrictive.
- 275 - 3. By cavitation and chemical.
- 275 - 4. Changes electrical energy into mechanical energy in the form of vibrations.
- 275 - 5. The formation of cavities within a liquid.
- 275 - 6. The high-pressure wave compresses the vapor liquid in the cavities.

- 275 - 7. The formation and bursting of the vapor pockets with their fantastic pressures and temperatures does the scrubbing.
- 275 - 8. Removing dissolved air and other gases in the cleaning solution.
- 276 - 1. a. Presoak.
b. Boil.
d. Condensate.
e. Test.
- 276 - 2. Boil.
- 276 - 3. To loosen the dirt in the filter element.
- 276 - 4. Presoak and cleaning.
- 276 - 5. By normal boil-condense cycle of the unit.
- 276 - 6. From the condensate tank.
- 276 - 7. Cleaning tank.
- 276 - 8. 1/2 inch above the filter being tested.
- 276 - 10. Points out a fault.
- 276 - 11. In individual clean plastic bags.
- 276 - 12. That they are dirty.
- 276 - 13. It should be rinsed with warm water and allowed to dry.
- 276 - 14. This indicates that the filters are clean. They should be tested in the test tank for serviceability.

1981-546-034/735 AUGAFS,AL(820432)2500





- A. Panel light
- B. Turbine speed indicator
- C. Panel lights switch
- D. Bleed air pressure gauge
- E. DC ammeter
- F. Panel light
- G. Control circuit breaker
- H. DC voltmeter
- I. AC ammeter
- J. Frequency indicator
- K. Panel light
- L. AC voltmeter

- M. AC contactor closed indicator light
- N. Voltage adjustment potentiometer
- O. AC contactor switch
- P. AC phase selector switch
- Q. DC contactor switch
- R. DC contactor closed indicator light
- S. Bleed air switch
- T. Bleed air ON light
- U. Master switch
- V. Turbine start switch
- W. Ready to load light
- X. Exhaust temperature indicator

Foldout 1. A/M32A-60 generator set instruments.

- S T O P -
1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
 2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

42354 02 21

PNEUDRAULIC FUNDAMENTALS, MATERIALS AND EQUIPMENT

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

42354-02-21

MULTIPLE CHOICE

1. (003) Which of the following statements defines Pascal's law?
 - a. The volume of an enclosed dry gas varies inversely within its pressure, provided the temperature remains constant.
 - b. All gases expand and contract in direct proportion to the change in the temperature, provided the pressure remains constant.
 - c. When a force is exerted on a confined fluid, the pressure is transmitted equally and undiminished in all directions.
 - d. As the fluid flow through the center of a venturi increases, the pressure decreases.
2. (004) Force in a pneudraulic system is determined by the amount of
 - a. fluid available.
 - b. volume from the pump.
 - c. distance an object is moved.
 - d. push or pull on an object.
3. (005) If a force of 100 pounds is applied to a cylinder piston having an area of 2 square inches and the resultant pressure is transmitted to another cylinder piston having an area of 4 square inches, what will is the resultant force on the second piston?
 - a. 800 pounds.
 - b. 400 pounds.
 - c. 200 pounds.
 - d. 100 pounds.
4. (006) Which of the following formulas best describes mechanical advantage?
 - a. Mechanical advantage equals pressure times volume.
 - b. Mechanical advantage equals resistance divided by effort.
 - c. Pi times radius squared equals mechanical advantage.
 - d. Add force and effort together to get mechanical advantage.
5. (007) What are the two types of fluid flow?
 - a. Smooth and turbulent.
 - b. Streamlined and turbulent.
 - c. Uniform and turbulent.
 - d. Laminar and turbulent.
6. (008) When liquid flows through a venturi, the pressure will be
 - a. the same throughout the venturi.
 - b. least at the throat of the venturi.
 - c. unaffected as the velocity decreases.
 - d. greatest at the throat of the venturi.

42354-02-21

7. (009) The law of conservation of energy states that energy can
- a. be created only.
 - b. be destroyed only.
 - c. either be created or destroyed.
 - d. neither be created nor destroyed.
8. (010) In the metric system of measurement the word "kilo" means
- a. hundreds.
 - b. thousands.
 - c. tens.
 - d. one.
9. (011) What are the three basic parts of an atom?
- a. Neutrons, protons, and electrons.
 - b. Neutrons, protons, and ions.
 - c. Neutrons, electrons, and freons.
 - d. Protons, electrons, and ions.
10. (012) Due to the small proportion of free electrons they contain, what substances may be used as insulators?
- a. Mica, silver, and rubber.
 - b. Mica, rubber, and copper.
 - c. Copper, bakelite, and glass.
 - d. Mica, glass, and plastics.
11. (014) Which unit in an aircraft hydraulic system serves the same function as a battery in an electrical system?
- a. An accumulator.
 - b. A relief valve.
 - c. A control valve.
 - d. An actuating unit.
12. (016) Use Ohm's law and determine the current in an electrical circuit that has a resistance of 12 ohms and a power supply of 48 volts.
- a. 2 amperes.
 - b. 4 amperes.
 - c. 24 amperes.
 - d. 96 amperes.
13. (017) In a series circuit, the total resistance is
- a. less than the largest resistor in the circuit.
 - b. the total of all the resistors in the circuit.
 - c. less than the smallest resistor in the circuit.
 - d. equal to the total current divided by the total voltage.

14. (018) The total current in a parallel circuit is
- equal to the product of the current flowing through all branches of the circuit.
 - equal to the current flowing through the largest branch of the circuit.
 - equal to the sum of the current flowing in the individual branches.
 - less than the smallest current through any branch of the circuit.
15. (019) To find the total resistance in a series-parallel circuit you should
- add the resistance of the parallel portion to the resistance of the series portion.
 - know the total current flow.
 - divide current flow by the applied voltage.
 - add the sum of the resistance in the parallel portion to the resistance of the series resistor.
16. (020) Which of the following statements is true of magnetic lines of force?
- They travel inside the magnet from north to south.
 - They travel externally from south to north.
 - They leave the magnet at the south pole and reenter the magnet at the north pole.
 - They travel externally from north to south.
17. (022) The strength of an electromagnetic coil is rated
- in ohms.
 - in ampere-turns.
 - by the type of core.
 - by the strength of the magnetic field.
18. (033) What is the purpose of the commutator segments attached to the armature of an electrical motor?
- To reverse the direction of the electrical motor.
 - To magnetize the armature.
 - To automatically change the polarity of the armature as it rotates.
 - To automatically collapse the magnetic field created by the armature.

19. (025) Why is hydraulic fluid MIL-H-5606 dyed red?
- a. To add life to the fluid.
 - b. For identification purposes.
 - c. To identify the amount spilled.
 - d. To increase the temperature range of the fluid.
20. (026) Solvents are best described as being
- a. liquids that dissolve other substances.
 - b. highly dangerous materials.
 - c. liquids that deteriorate metals.
 - d. completely useless when cleaning aircraft parts.
21. (216) A static seal would be used
- a. in brake assembly pistons.
 - b. on pump drive shafts.
 - c. as a seal between two stationary parts.
 - d. in actuating cylinder pistons.
22. (216) One of the main reasons that MS 28775 and MS 28778 seals were developed was that
- a. AN6227 and AN6290 were too soft.
 - b. AN6227 and AN6290 seals were hard to install.
 - c. AN6227 and AN6290 seals have a higher temperature range.
 - d. AN6227 and AN6290 seals have a lower temperature range.
23. (217) Seals are individually wrapped in sealed packages to
- a. insure a positive identification.
 - b. keep the seals open.
 - c. make it easier to handle them.
 - d. prevent deterioration.
24. (032) What type of lubricant is recommended for use in pneumatic systems?
- a. MIL-G-4273.
 - b. MIL-G-4343.
 - c. MIL-H-5606.
 - d. VV-P-236.
25. (219) Backup rings are unnecessary in a hydraulic system when the operating pressure does not exceed
- a. 1500 psi.
 - b. 1600 psi.
 - c. 1800 psi.
 - d. 2000 psi.

42354-02-21

26. (220) What insures that the mating ring stays in contact with the sealing ring as it wears?
- a. Fluid pressure.
 - b. The lock washer.
 - c. The spring.
 - d. The O-ring seal.
27. (221) Overtightening a B nut on a flared fitting may
- a. result in a permanently sealed joint.
 - b. squeeze out all the usable lubricant from the threads.
 - c. necessitate the use of a thread compound for removal.
 - d. badly damage or completely cut off the tube flare.
28. (222) Which of the following tube assemblies may have damage that is beyond technical order limits?
- a. A dent on the heel of a bend.
 - b. A dent on a straight piece of tubing which is 17 percent of the tubing diameter.
 - c. A nick on a straight piece of tubing which is 10 percent of the wall thickness.
 - d. A scratch on the bend of tube assembly that is 2 percent of the wall thickness.
29. (222) What is the advantage of using the permaswage repair procedure over local manufacture of a new tube assembly?
- a. It will last longer than a locally manufactured tube assembly.
 - b. The bends, length, and angles will almost be the same as the original tube assembly.
 - c. It requires less tools to repair than to manufacture.
 - d. it costs less to repair than to manufacture a tube assembly.
30. (223) Bulk hose, specification number MIL-H-8788 indicates that this hose is a
- a. medium pressure rubber hose.
 - b. high pressure rubber hose.
 - c. high pressure teflon hose.
 - d. medium pressure teflon hose.
31. (224) The advantage of a pneudraulic hose over tubing is its
- a. flexibility.
 - b. ease of manufacturer.
 - c. cost.
 - d. durability.

32. (224) According to the text, the first step in the fabrication of medium-pressure Teflon hose assemblies is to
- reuse all medium-pressure fittings if serviceable without exception.
 - be sure to reuse all serviceable hose.
 - select the proper size bulk hose and end fittings.
 - cut the hose squarely and to the required length.
33. (225) Why should a heavy plastic cover be used over the hose assembly when proof testing a hose?
- To prevent leakage.
 - To keep the area clean in case the hose should rupture.
 - To hold the hose down during testing.
 - To provide protection for the person testing the hose.
34. (225) What should be done to a hose that is drawn from supply, if the only marking etched on the hose socket is the manufactured date (assembled date)?
- Nothing. The assembled date will be considered as the installation date.
 - The installation date will have to be etched on another flat surface of the socket also.
 - The assembled date will have to be obliterated and the new assembled date etched on the next flat spot.
 - The hose will have to proof pressure tested and then the date of this proof pressure test etched on the socket.
35. (226) When any portion of the metal reinforcement on MIL-H-8794 of MIL-H-8788 hose assemblies is exposed or damaged, the mechanic should as a safety precaution
- replace the outer covers.
 - replace the hose.
 - reinforce the exposed portion with tape.
 - cover the exposed portion with a rubber coating.
36. (227) How are the systems identified for tubing and hoses which are used to transfer fluid and gases on an aircraft?
- By painting with international orange paint.
 - By the hose or tubing specification.
 - By the coded bands of colored tape.
 - By the metal tags attached to each tube or hose.

37. (228) A blue-colored fitting is usually a standard
- a. AN steel fitting.
 - b. MS steel fitting.
 - c. AN aluminum alloy fitting.
 - d. MS aluminum alloy fitting.
38. (229) Antiseize material is used on
- a. flareless fittings only.
 - b. pipe thread fittings only.
 - c. flared tube fittings only.
 - d. all types of fittings.
39. (29) When installing a universal fitting into a bosc and the seal is firmly against the boss, you should then turn the fitting
- a. 1/2 turn.
 - b. 3/4 turn.
 - c. 1 turn.
 - d. 1 1/2 turn.
40. (230) The size of a bolt is generally stated in terms of
- a. the type of head and threads per inch.
 - b. the length, diameter, and threads per inch.
 - c. the diameter and threads per inch.
 - d. either the slotted or recessed head.
41. (231) What is the maximum number of bolts that can be safetied together using the double twist method of safety wiring?
- a. 6.
 - b. 4.
 - c. 3.
 - d. 2.
42. (231) What size of safety wire should be used when using the single-wire method of safety wiring?
- a. The smallest size wire should always be used.
 - b. The largest size wire that the safety wire hole will accomodate.
 - c. It makes no difference as long as the wire is tight.
 - d. 0.020 steel wire only.
43. (232) The purpose of a turnbuckle is to
- a. adjust the tension on the aircraft's cable.
 - b. to release the tension on aircraft cables.
 - c. connect or disconnect the aircraft cables quickly.
 - d. prevent the aircraft cables from chaffing against the aircraft frame.

44. (233) What is the advantage of using a rubber-cushioned clamp over a teflon clamp?
- a. It will not deteriorate from harmful chemicals.
 - b. It will not tear.
 - c. It will be easier to install.
 - d. It provides an excellent cushioning against vibration.
45. (234) How are ball peen hammers classified?
- a. According to their size.
 - b. By the length of the handle.
 - c. According to the weight of the head without the handle.
 - d. By the type of material in the hammer head.
46. (234) Which of the following hammers would you use to avoid metal damage?
- a. A tack hammer.
 - b. A ball peen hammer.
 - c. A common hammer.
 - d. A mallet.
47. (235) When using an emery wheel to reshape a common screwdriver, you should do all of the following except to
- a. use a light pressure.
 - b. make the end square and the sides practically parallel.
 - c. remove as little metal as possible.
 - d. remove the temper.
48. (236) Which of the following pliers are best suited for holding objects in tight places and for making delicate adjustments?
- a. A diagonal-cutting pliers.
 - b. A combination slip-joint pliers.
 - c. A water pump pliers.
 - d. A needle-nose pliers.
49. (237) An adjustable jaw wrench is properly used when
- a. the handle is pushed away from you.
 - b. the handle is pulled away from the jaw.
 - c. the pulling force is applied to the stationary jaw.
 - d. a pipe or extension is added to gain leverage.
50. (237) The box end wrench cannot be used for removing
- a. actuator mount bolts.
 - b. high torque nuts.
 - c. nut or bolts in tight places.
 - d. B nuts on installed tubing.

51. (237) To loosen a nut or a capscrew, you should first use a
- a. hinge handle.
 - b. speed handle.
 - c. ratchet.
 - d. strap wrench.
52. (238) A flexible type hacksaw blade should be used when cutting
- a. cast iron.
 - b. tool steel.
 - c. tubing.
 - d. brass stock.
53. (239) Which statement listed below concerning a file is correct?
- a. Never draw the file backward.
 - b. Never oil a file as it will cause it to load.
 - c. A double-cut file will give a smoother cut.
 - d. Allow the file to load since it will give you a smoother operation.
54. (240) Before beginning a drilling operation, what should be done to prevent the drill from "wandering"?
- a. Draw a circle around the hole with a scribe.
 - b. Make sure that the drill is held at a 45° angle.
 - c. Indent the drill location with a center punch.
 - d. Place a drop of oil on the place to be drilled.
55. (241) The thickness gage is used to
- a. measure the clearance between two surfaces.
 - b. measure the thickness of an item.
 - c. compare the threads of nuts and bolts.
 - d. measure the outside diameter of a tube.
56. (242) What two types of manometers are most commonly used in the pneudraulic shop?
- a. Hydraulic fluid and air.
 - b. Water and hydraulic fluid.
 - c. Mercury and hydraulic fluid.
 - d. Water and mercury.
57. (242) When using a water manometer, approximately how many inches of water pressure would be equal to 1 psi?
- a. 2.036.
 - b. 14.7.
 - c. 15.
 - d. 28.
58. (243) How is the total movement of a dial indicator read?
- a. By adding the minus readings only.
 - b. By adding the minus reading and subtracting the plus reading.
 - c. By subtracting the minus reading from the plus reading.
 - d. By adding the minus reading to the plus reading.

42354-02-21

59. (244) If a tensiometer is suspected of being incorrect, you should
- a. condemn it.
 - b. repair it.
 - c. check it with the use of a test bar.
 - d. send it back to supply.
60. (245) Which of the following statements is true about using an outside micrometer?
- a. The micrometer should be tightened enough to hold its own weight.
 - b. Each complete revolution of the thimble will move the spindle 0.025 inch.
 - c. The object to be measured is placed squarely between the face and the spindle.
 - d. Each major graduation on the barrel is equivalent to one revolution of the thimble.
61. (246) The torque wrench is designed to measure
- a. inch-pounds or foot-pounds.
 - b. only inch-pounds.
 - c. only foot-pounds.
 - d. pounds per square inch.
62. (246) How can you readily tell if a torque wrench has been verified?
- a. By the date of calibration stamped on the handle.
 - b. By checking the serial number of the torque wrench against the next due calibration date in the tool crib.
 - c. By a color coded date tape placed on the torque wrench.
 - d. By the next date of calibration which is fastened to the handle.
63. (247) If you have a component that needs to be torqued to 1800 inch-pounds, but only have a torque wrench that measures foot-pounds, what should you do?
- a. Divide 12 into 1800.
 - b. Multiply 12 times 1800.
 - c. Divide 1800 into 12.
 - d. Subtract 12 from 1800.

64. (248) Where would you go to find what special tools are needed to overhaul a hydraulic component?
- a. They can be found in the index technical orders.
 - b. They can be found in the special tools section of the overhaul instructions technical order.
 - c. They can be found only in the -4 illustrated parts breakdown of technical orders.
 - d. They can be found in the -6 inspections technical orders.
65. (248) Why would some tools need to be redesigned or locally manufactured?
- a. This is not authorized and should not be done under any circumstances.
 - b. Because these tools take too long to order from supply.
 - c. To accommodate unusual maintenance situations.
 - d. Because the shop can not show justification for these tools.
66. (249) If a pressure gage is sent to the PMEL, what will they do to show that it has been checked (or calibrated)?
- a. An AFTO Form 256 will be placed in the gage's container.
 - b. Nothing, because gages do not have to be checked.
 - c. An AFTO Form 255 will be attached to the glass of the gage.
 - d. They will affix an AFTO Form 108 on a conspicuous place upon the item.
67. (249) Whenever an item of equipment is borrowed from your shop, you should have the borrower sign for it on
- a. AF Form 349.
 - b. AF Form 350.
 - c. AF Form 781A.
 - d. AF Form 1297.
68. (250) The purpose of the AN/PSM-6 series VOM is to measure
- a. resistance, frequency, and ohms.
 - b. ohms, volts, and amperes.
 - c. amperage, resistance, function, and range.
 - d. frequency, amperes, and resistance.
69. (250) The range selector switch setting on the AN/PSM-6 series VOM which should be used when checking 28 VDC is
- a. DCV-20K/V.
 - b. DCMA.
 - c. 30 volt.
 - d. 50 volt.

70. (250) To measure current accurately the VOM is connected to the circuit under test in
- a. series.
 - b. parallel.
 - c. any manner as long as power is applied.
 - d. any manner as long as power is not applied.
71. (251) The purpose of zeroing the pointer on the ultrasonic leak detector is to
- a. compensate for battery wear.
 - b. eliminate an indication of surrounding noises.
 - c. prevent damage to the meter scale from loud noises.
 - d. protect the sensitive sensing probe.
72. (252) An operator jacking an aircraft is having extreme difficulty in operating the handle of the 6-ton tripod jack. If the capacity of the jack is adequate, he should next check
- a. the position of the fulcrum.
 - b. the position of the needle valve.
 - c. the grooves in the ram for cleanliness.
 - d. for air under the ram.
73. (252) Axle jacks are often used instead of tripod jacks, when
- a. brakes or tires are being worked on.
 - b. a tripod jack is not available.
 - c. an aircraft is located on the flight line.
 - d. an aircraft is in the hangar.
74. (253) It is important that you remove aircraft jacks as soon as you have lowered the weight of the aircraft onto its landing gears, because
- a. a hydraulic leak on the jack may occur.
 - b. someone else may be in need of the jack.
 - c. the shock strut may bind.
 - d. it is fire hazard to leave a jack under an aircraft.
75. (254) To prevent the accidental lowering of a B-1 maintenance stand, you must be sure that the
- a. bypass valve is closed.
 - b. safety lock is used.
 - c. ram locknut is screwed down tightly.
 - d. platform load does not exceed 500 pounds.

76. (254) What could happen if the platform on the B-4 or B-5 maintenance stands is raised or lowered while personnel are standing on the ladder?
- a. It could cause the actuator to leak.
 - b. The platform may be damaged.
 - c. The reservoir and pump could bind against the ladder.
 - d. Injury to the feet of personnel may occur.
77. (255) When servicing a component with the nitrogen servicing cart (MD-3), how many lever-operated valves should be open when charging?
- a. Never have more than one lever operated valve open at any one time.
 - b. Have all the valves open.
 - c. Have at least two lever valves open.
 - d. Have all the cam lever valves open.
78. (256) What will prevent an excessive pressure buildup in either the high pressure or low pressure pump systems on the hydraulic servicing cart?
- a. A shut-off valve.
 - b. A relief valve.
 - c. A check valve.
 - d. A filter assembly.
79. (256) Why should some form of cap or plug be used on the servicing hose of the hydraulic servicing cart?
- a. To prevent the possibility of contamination when the servicing cart is not being used.
 - b. To allow pressure to build up in the hose.
 - c. To prevent the pressure from the low pressure pump from entering the manifold.
 - d. To prevent the pressure from the high pressure pump from entering the manifold.
80. (257) The supply system of the MJ-2A hydraulic test stand consists of the
- a. pump, filters, and relief valve.
 - b. reservoir, filter, and pump.
 - c. return lines, filters, and coolers.
 - d. reservoir and the fill system.
81. (257) How can dirty fill system filters on the MJ-2A best be determined?
- a. By checking the low pressure system gauge.
 - b. By inspecting the filters.
 - c. By observing the duplex gauge.
 - d. By removing a fluid sample from the filter housing.

82. (257) When ready to fill the system of the MJ-2A hydraulic test stand, you must put the reservoir selector valve in the
- a. external position.
 - b. stand position.
 - c. fully closed position.
 - d. full open position.
83. (258) The purpose of the low-pressure system on the hydraulic test stand to insure a constant flow of fluid to the
- a. relief valve.
 - b. aircraft pumps.
 - c. low pressure filters.
 - d. main pump.
84. (258) If the warning horn should sound during the low-pressure system operation of the hydraulic test stand, this would indicate
- a. an excessive boost pressure.
 - b. a low boost pressure.
 - c. a low engine temperature.
 - d. an excessive fluid temperature.
85. (259) The presence of excessively dirty high pressure filters on the MJ-2A is indicated by the
- a. differential pressure gage.
 - b. filter warning light.
 - c. warning horn.
 - d. test stand automatically shutting down.
86. (259) In the MJ-2A hydraulic test stand the high pressure pump is controlled by the
- a. flow control valve.
 - b. volume flow gauge.
 - c. pressure compensator and volume control.
 - d. flowmeter assembly.
87. (259) In order to send an output from the MJ-2A hydraulic test stand to the aircraft you must
- a. open the flowmeter control valve and open the bypass through flowmeter valve.
 - b. open the flow valve and close the compensator valve.
 - c. open the flow control valve and close the bypass through flowmeter valve.
 - d. close the flow control and bypass through flowmeter valves.

88. (260) If the position of the reservoir selector valve is changed in the MJ-2A during operation, the operator may cause the
- aircraft reservoir to overfill.
 - flowmeter to be smattered.
 - return system pressure to decrease.
 - flow control valve seals to rupture.
89. (260) The air compressor on the MJ-2A test stand pneumatic system is directly driven by
- the engine through the gear case.
 - a 24-volt electric motor.
 - a hydraulic motor.
 - a V-belt from the cooling fan drive shaft.
90. (261) One of the first things that should be done before operating any piece of aerospace ground equipment is to
- check oil.
 - service the unit with oil and grease.
 - review the maintenance forms.
 - check the exterior of the unit for damage.
91. (262) The appearance of a pink, milky fluid in the sight tube of the MJ-2A hydraulic test stand indicates
- water in the system.
 - an overheated hydraulic fluid.
 - that the wrong kind of fluid is being used.
 - air in the system.
92. (262) If after starting the MJ-2A hydraulic test stand, the engine oil pressure does not build up
- you should wait until the engine pressure switch shuts the test stand down.
 - stop the unit at once.
 - the warning horn will sound.
 - the engine oil indicator light will come on.
93. (262) In order to check the relief valve operation of the MJ-2A hydraulic test stand, you must first
- close the bypass through flowmeter valve.
 - open the bypass through flowmeter valve.
 - set the relief valve.
 - open the flow control valve.

94. (263) The MC-1A air compressor air cleaner is of what type?
- a. Mesh.
 - b. Screen.
 - c. Dry.
 - d. Oil bath.
95. (263) At what pressure should the MC-1A air compressor priority valve open?
- a. 2400 psi.
 - b. 2800 psi.
 - c. 3300 psi.
 - d. 3500 psi.
96. (264) What automatically unloads the compressor when the pressure reaches 3500 psi?
- a. The priority valve.
 - b. The safety valve.
 - c. The pressure switch.
 - d. The blow out disc.
97. (265) If the receiver pressure gauge on the MC-1A is showing a pressure reading before 2400 psi is reached, what component is probably at fault?
- a. The check valve.
 - b. The priority valve.
 - c. The 3500 psi pressure switch.
 - d. The solenoid operated drain switch.
98. (266) The use of an MD-3 generator set saves which of the following from prolonged use on the ground when checking the operation of electrical system units?
- a. The engine and ignition system.
 - b. The engine and starter generator.
 - c. The aircraft instrument system and engine.
 - d. The aircraft engines and electrical supply system.
99. (267) Within how many seconds should oil pressure come up after starting the MD-3 generator set?
- a. 10.
 - b. 20.
 - c. 30.
 - d. 40.
100. (267) What is the maximum speed at which an MD-3 generator set should be operated with the drive mechanism engaged?
- a. 2 mph.
 - b. 5 mph.
 - c. 7 mph.
 - d. 10 mph.

101. (268) After the A/M32A-60 generator set has reached 95 percent of governed speed, the operator should
- a. set the AC contactor switch to RESET then to OPEN.
 - b. connect the power cables.
 - c. adjust the governed speed.
 - d. connect the bleed air duct.
102. (268) In the A/M32A-60 generator set, what will happen if the exhaust temperature becomes excessive while using both pneumatic and electrical loads?
- a. The warning horn will sound.
 - b. The pneumatic load will be dropped.
 - c. The unit will automatically shut down.
 - d. The electrical load will be dropped.
103. (269) How many major test circuits are on the HCT-6 test stand?
- a. 3.
 - b. 5.
 - c. 7.
 - d. 10.
104. (269) The cylinder test circuit selector valve on the HCT-6 test stand must be in the FLOWMETER RETURN position when you are adjusting the
- a. volume output of the stand.
 - b. pressure output of the stand.
 - c. relief valve.
 - d. temperature controller.
105. (269) Which of the following units on the HCT-6 test stand measures the internal pump leakage of a pump under test?
- a. The leakage tank.
 - b. The 0.4 to 4 gpm flowmeter.
 - c. The scavenge flowmeter.
 - d. The suction flow indicator.
106. (270) Whenever the suction filter becomes clogged the filter pressure switch causes the lamp on the control panel to
- a. come on.
 - b. go off.
 - c. start flashing.
 - d. activate a warning horn.

107. (270) What could possibly happen if the HCT-6 test stand relief valve is adjusted below 500 psi?
- a. It would relieve pressure back to the suction manifold.
 - b. It could damage the seals in the valve.
 - c. It may strip the threads on the adjusting knob.
 - d. It will burst from too much pressure.
108. (270) The manometer circuit of the NCT-6 test stand is primarily used
- a. in conjunction with the pump test.
 - b. in hose testing.
 - c. to indicate the fluid temperature.
 - d. to measure the amount of cooling water entering the stand.
109. (271) Prior to operating the HCT-6 test stand, why should you pressurize,, depressurize, and the repressurize the reservoir?
- a. This will release all the stored pneumatic pressure in the system.
 - b. It will make the fluid foam.
 - c. It will insure that all lines are completely filled with fluid.
 - d. It will cool the fluid in the reservoir.
110. (272) One the hose out off and skiving machine, what interrupts power to the drive motor if the motor exceeds full-load current by an excessive amount?
- a. A reset switch
 - b. An overload switch.
 - c. An overload valve.
 - d. A thermal reset button.
111. (272) The oil-fog lubricating system on the hose out off and skiving machine is used not only for lubricating the cutting blade but also for
- a. sharpening the blade during curring operations.
 - b. cleaning the blade after the cutting operation is finished.
 - c. increasing the speed of the blade during cutting operations.
 - d. cooling the blade during cutting operations.

112. (272) When using the skiving section of the hose cut off and skiving machine, how can you tell if the hose has been skived properly?
- a. When the wire braid looks burnt.
 - b. When all the rubber has been removed.
 - c. When the wire braid appears bright, but the wires are not disturbed.
 - d. When the twisted wire braid has been straightened.
113. (273) How often should the cutting blade of the hose cut off and skiving machine be inspected?
- a. At least every 30 days.
 - b. At least every 40 days.
 - c. Yearly.
 - d. Weekly.
114. (274) The advantage of making hoses with the hose assembly machine over the hand method is that the machine can
- a. make any size hose assembly.
 - b. make size 2 through 48 medium-pressure hose assemblies.
 - c. be used mainly for making hose assemblies using the flange-type fittings.
 - d. rapidly produce medium or high-pressure hose assemblies within its limits.
115. (274) The de-clutching button on the handle of the control switch of the hose assembly machine
- a. is operational only when the clutch control box switch is in JOG position.
 - b. is operational when the clutch control box switch is in RUN position.
 - c. is operational only in reverse direction.
 - d. produces a maximum torque in the run position.
116. (275) What happens when the dissolved air and other gases are trapped in the cleaning solution of the Sane 50?
- a. The transducers will burn up.
 - b. Cleaning will not be effective until the liquid is completely degassed.
 - c. The cleaning solution will have to be changed.
 - d. This will help in the cleaning process.

117. (276) Which of the tanks in the Sane 50 have sonic units?
- a. The boil and cleaning tanks.
 - b. The presoak and cleaning tanks.
 - c. The condensate and test tanks.
 - d. The presoak and test tank.
118. (274) What is the proper sequence in which the tanks should be used when cleaning and testing a filter element in the Sane 50?
- a. Presoak, cleaning, and test.
 - b. Clean, presoak, boil, and test.
 - c. Presoak, boil, and condensate.
 - d. Clean, boil, condensate, and test.

42354-02-21

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**AIRCRAFT PNEUDRAULIC SYSTEMS
MECHANIC**

(AFSC 42354)

Volume 3

Pneudraulic Components



Extension Course Institute

Air University

438

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IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN VOLUME 2 we discussed hydraulic principles and laws. They determine how units and systems will be built and what they can and cannot do. It is important that you have a basic knowledge of the principles of operation of these units. You may frequently be called upon to diagnose aircraft hydraulic system troubles; you can do this only if you are familiar with the units in the system. With this knowledge you will be equipped to more easily isolate system troubles.

The units that we shall describe in this and the following chapters may be divided into groups. The first chapter contains those units necessary to provide the system with a fluid supply. It includes reservoirs and pumps. The second chapter covers the units most commonly found in the power section of an aircraft system. The third chapter discusses pressure indicating units, such as gages and transmitters. The fourth and fifth chapters cover components that convert the pneudraulic power back into a mechanical power at a distant point. And finally, the sixth chapter covers landing gear system components.

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Contents

		<i>Page</i>
	<i>Preface</i>	iii
<i>Chapter</i>		
1	Hydraulic Power Supply Components	1
2	Hydraulic and Pneumatic Power System Components	19
3	Indicating System Components	49
4	Selector Valves and Actuators	63
5	Subsystem Pressure and Flow Valves	88
6	Landing Gear Components	103
	<i>Answers for Exercises</i>	131

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Hydraulic Power Supply Components

THE VARIETY of aircraft in the Air Force inventory present the pneudraulic systems mechanic with a variety of hydraulic power systems on which to work. These systems contain many different components. In this chapter, we shall concern ourselves with two components found in all hydraulic power supply systems.

The first section of this chapter is on reservoirs. The discussion includes both the pressurized and the non-pressurized types. Along with this, we present simple schematics to show how the units are situated in pressurized and nonpressurized systems. The second section of this chapter is on pumps. It discusses pumps which are most commonly used throughout the pneudraulic career field. Some of these pumps are constant volume, and others are variable volume.

1-1. Hydraulic Fluid Reservoirs

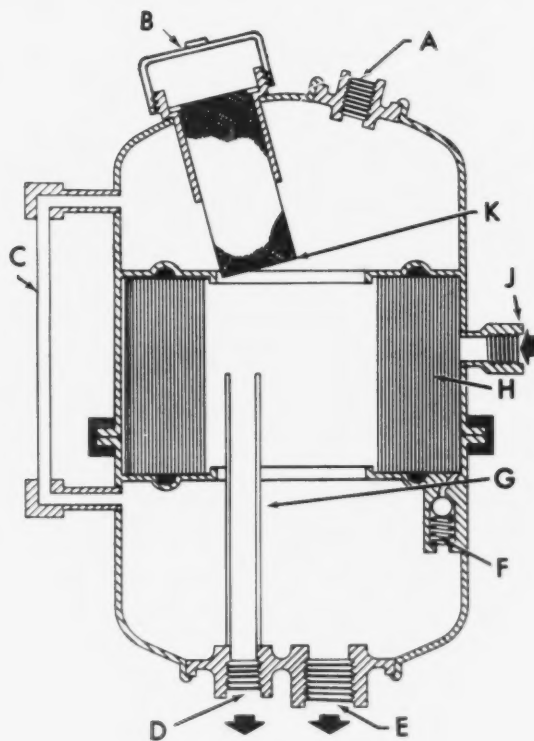
The reservoir is the fluid "storehouse" for the aircraft hydraulic system. The size and shape of each reservoir has been carefully engineered to fit each aircraft. Basically, the reservoir is a tank in which an adequate supply of fluid for the system is stored. It should contain enough fluid to supply the normal operating needs of the system, along with an additional amount to replace fluid lost through minor leakage. Furthermore, the reservoir serves as an overflow basin for excess fluid forced out of the system by thermal expansion, by the dumping of accumulators, and by actuator piston rod displacement. The reservoir also furnishes a place for the fluid to purge itself of air bubbles which may enter the system. Reservoirs are of two general types—nonpressurized and pressurized.

400. Indicate whether given statements correctly reflect the nonpressurized reservoir and vent filter construction.

Nonpressurized Reservoir. A nonpressurized reservoir is shown in figure 1-1. Most reservoirs of this type have a space above the fluid, even when they are full. This allows the fluid to purge itself of air bubbles that are picked up from the system. The sight gage (C) gives a visual indication of the amount of fluid in the reservoir. It is a glass tube which usually has markings such as "full" and "refill" along its side. If the reservoir needs to be serviced, it is serviced through the filter cap (B) and wire screen (K). This wire screen is commonly called a finger screen. It prevents foreign matter from entering the reservoir while it is being serviced. Under non circumstances should the reservoir be serviced with hydraulic fluid of an unknown origin. A new can should be opened each time you fill the reservoir.

In some reservoirs, filter elements (H) are placed inside the reservoir to insure the cleanliness of the fluid entering through the return port (J). Should the filter element become clogged, the relief valve (F) will open to let the fluid bypass the filter element and enter the main part of the reservoir. In this case, the valve is set to open at pressures above 12 psi.

On some aircraft the emergency hydraulic system gets its fluid from the main system reservoir. In such systems, a standpipe (G) is connected to the main system or power pump outlet (D). Let's assume that a line were to rupture somewhere in the main system. If this happened, the pump would continue to pump fluid overboard until the supply became exhausted, and it would be impossible to maintain any pressure in the system. The standpipe prevents the main system pump from taking fluid whenever the level drops below the top of the standpipe. This keeps enough fluid in the bottom of the reservoir to supply the emergency pump through the emergency pump outlet (E). If a



42-178

- | | |
|----------------------|-------------------|
| A. Vent port | F. Relief valve. |
| B. Reservoir cap | G. Standpipe |
| C. Sight gage | H. Filter element |
| D. Power pump outlet | J. Return port |
| E. Hand pump outlet | K. Screen |

Figure 1-1. Typical hydraulic fluid reservoir.

standpipe is not incorporated in the reservoir, a separate reservoir must be used for emergency operation.

The vent port (A) at the top of the reservoir is vented to the atmosphere. Atmospheric pressure at sea level (14.7 psi) can enter to force the fluid to the pump. This prevents a vacuum from being formed as the fluid level in the reservoir is lowered. The vent also makes it possible for air to be expelled from the reservoir when large volumes of fluid are returned from the system.

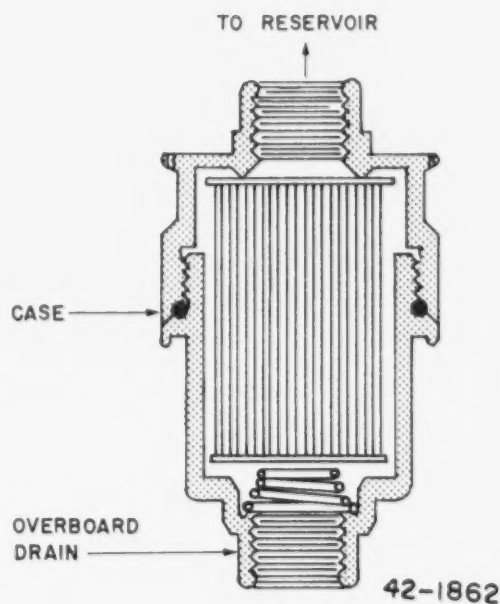
A filter is usually installed in the vent port of a reservoir to filter out foreign material from the air entering the reservoir. (See fig. 1-2.) The case is constructed in two parts. One part of the case screws into the other half. Inside is a filter element and a spring, which pushes the filter element up tight against the top. The ambient air, or in some cases pressurized air, enter the drain port, flows around the outside of the filter element, and enters the reservoir. The filter element can be replaced

periodically or whenever it becomes dirty. When installing the vent filter on the aircraft, make sure the end of the filter marked "res" is attached to the line going to the reservoir.

Exercise (400):

Indicate whether the following statements are true or false by placing a T or F in the blank preceding the statement. Correct the false statements.

- ___ 1. Most nonpressurized reservoirs have a space above the fluid.
- ___ 2. The vent port filter is used to filter out foreign material from fluid returning from the system.
- ___ 3. The finger screen is used to prevent foreign material from entering the reservoir during servicing.
- ___ 4. The sight gage is a metal rod.



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Figure 1-2. Vent filter.

- 5. The relief valve in the reservoir relieves excess main system pressure.
- 6. The standpipe will supply fluid to the emergency system.

401. Specify how a suction boost system is constructed and how it operates to insure a positive supply of fluid to the power pumps.

Suction Boost Pump System. Figure 1-3 illustrates a suction boost pump system. The suction boost pump is a centrifugal pump, driven by an electric motor. Figure 1-4 shows a centrifugal pump. This pump consists of a housing with an inlet port and outlet port. The drive shaft turns an impeller (something like a paddle wheel on a steamboat) at a very high speed. The fluid enters the inlet port and is supplied to the rotating impeller near its center. The impeller blades sling the fluid outward from the center, causing the fluid to exit through the outlet port. With this type of pump a relief valve is not necessary, because of the clearance between the impeller and housing. This

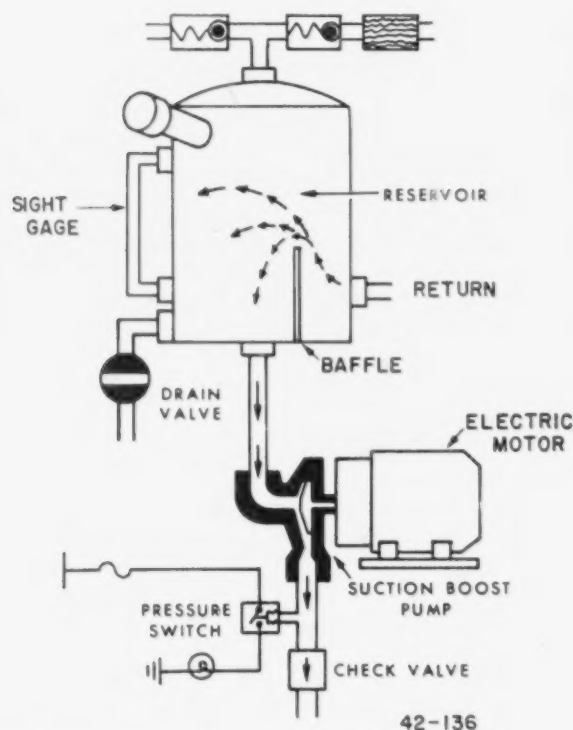


Figure 1-3. Suction boost pump system.

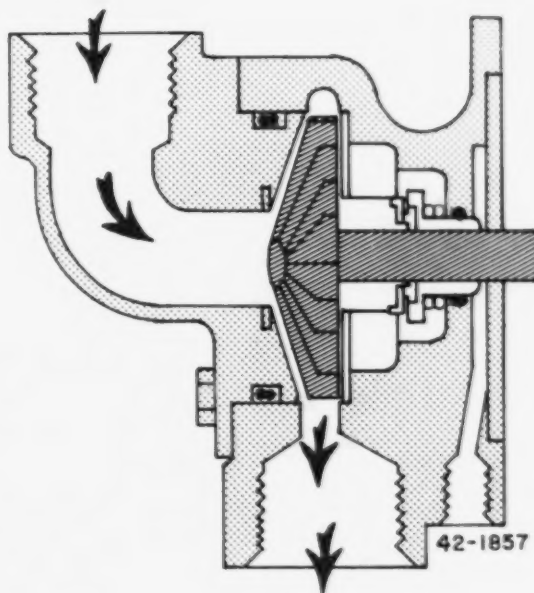


Figure 1-4. Centrifugal pump.

allows some of the fluid to seep back into the intake port if the pressure builds up too high on the outlet port. This pump supplies a large volume of fluid at low pressure, as much as 20 gallons or more per minute with a pressure of 70 to 100 psi. This will insure an adequate supply of fluid to the engine-driven pump(s). Refer again to figure 1-3 as we continue discussing the suction boost pump system. Downstream from the suction boost pump is a pressure switch. The pressure switch is connected to a warning light which will illuminate anytime the pressure is below 25 psi. Downstream from the pressure switch is a check valve. The check valve is installed to prevent a reverse flow from the pump to the reservoir when the system is not in operation. Inside the reservoir, a baffle prevents the fluid that is returning from the system from going directly to the suction line. The baffle makes the fluid mix with the fluid in the reservoir, thus cooling the fluid before it again goes out to the pumps. On top of the reservoir are two check valves. These valves prevent fluid loss from the reservoir during turning, diving, and climbing. One check valve allows filtered air to enter the reservoir during system operation. The other check valve allows air to escape into the atmosphere if the pressure inside the reservoir builds up too much.

Exercises (401):

Refer to figure 1-3 to answer question on the boost pump system.

1. Why is a relief valve not needed in the suction boost pump system?

2. The centrifugal pump supplies a _____ volume of fluid at _____ pressure.
3. At what points does fluid enter and leave a centrifugal pump?
4. Why is a baffle installed inside the reservoir?
5. Why are the check valves installed on top of the reservoir?
6. What unit in the suction boost pump system insures that the engine driven pump has an adequate supply of fluid?
7. What indicates a fluid pressure below 25 psi?
8. What unit prevents a reverse flow from the pump to the reservoir when the suction boost pump system is not operating?

402. State two reasons why reservoirs are pressurized, and specify how a reservoir can be pressurized by hydraulic pressure.

The Purpose of Reservoir Pressurization. In most hydraulic systems, it is necessary to pressurize the fluid reservoir. This is especially true in high altitude flying aircraft. Pressurizing the reservoir does two things; first, it stops the fluid from foaming at high altitudes; second, it insures a positive supply of fluid to the pumps. As you know, the atmosphere pressure decreases as the aircraft altitude increases; and, when there is little or no pressure on the fluid, it tends to foam. Foaming in the reservoir will cause air bubbles to form throughout the fluid; this introduces air into the system. Also the pumps will be starved for fluid because the low atmospheric pressure found at high altitudes is applying very little pressure to push the hydraulic fluid out of the reservoir. This can result in cavitation (the development of a cavity) in the suction line of the power pump. The effect is like a vapor lock on an automobile fuel pump. The remedy is to pressurize the reservoir.

Hydraulic Pressure Pressurized Reservoirs. A nonpressurized reservoir can use a suction boost pump to pressurize the fluid and sent it to the main hydraulic pumps. In this section, we will discuss the pressurization of a reservoir by hydraulic fluid, which in turn forces the fluid from the reservoir to the main system pumps. To pressurize the reservoir in this system, spring tension and system pressure are used. It must be emphasized that by no means is this the only type of hydraulic reservoir pressurization.

Refer to figure 1-5. The reservoir consists of a barrel (C) with a pump supply line (N), system return line (O), filler valve (A), and relief valve vent line (B). All these lines are pressurized to the same valve. They also have the same pressure as the fluid confined in the area between the reservoir piston (D) face and the barrel (C).

The opposite end of the reservoir is referred to as the head (F). It contains the piston spring (E), pressurization piston (L), system pressure line (H), indicator rod (G), and relief valve (J).

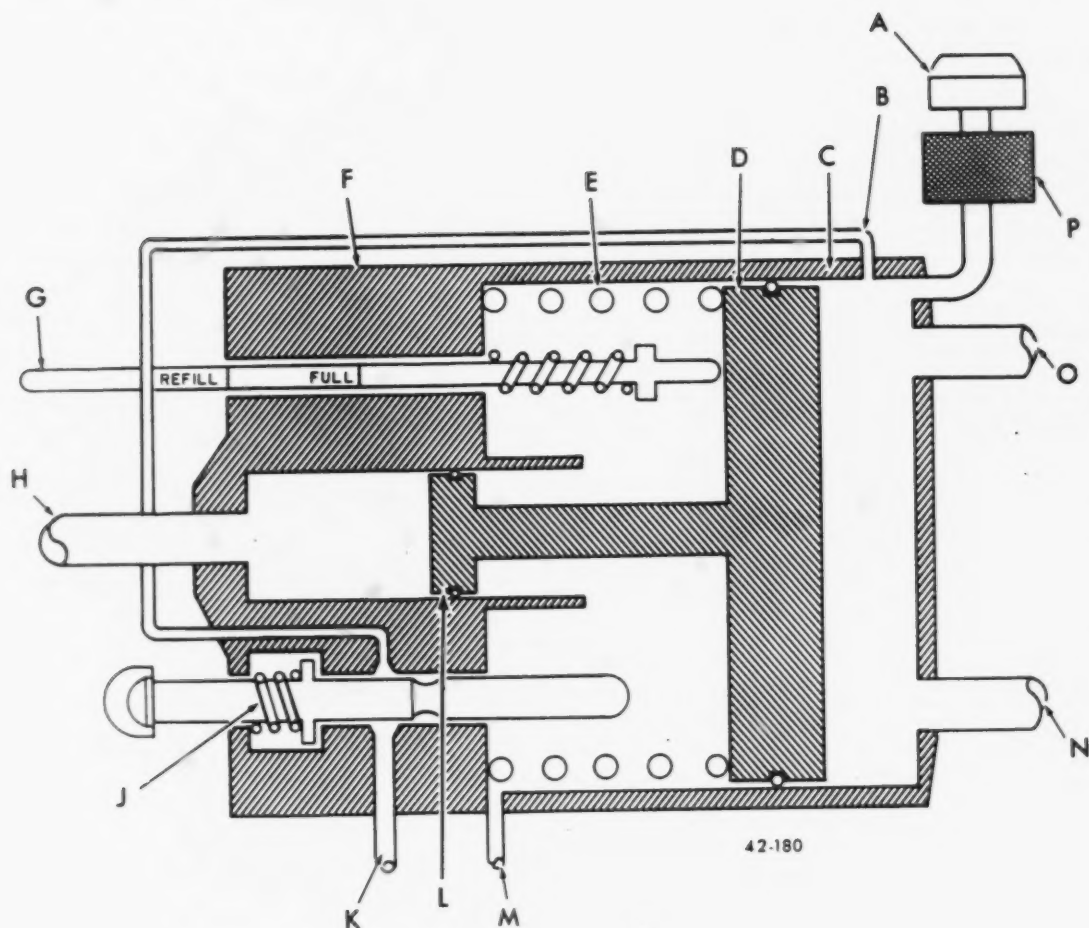
With the reservoir at the full level, the piston spring (E) will force the reservoir piston (D) to the right. This pressurizes the reservoir fluid to 5 psi. When the power pump is operating, the system pressure line (H) is pressurized to 3000 psi. System pressure acting on the pressurization piston will cause the reservoir piston (D) to push harder to the right. This increased force will be enough to pressurize the reservoir fluid to 30 psi. Referring to figure 1-5, notice that any leakage past the piston (D and L) seals should drain off through the overboard drain line (M) in the lower section of the reservoir barrel (C).

The reservoir is pressure-filled through a self-sealing filler valve (A), using a portable servicing cart. When not in use, the filler valve is protected by a dust cap. An in-line screen-type filter (P) is installed in the fill line. This filler prevents foreign objects from entering the reservoir during servicing operation. A direct reading indicator rod (G) is mounted in the reservoir head (F). It is a spring-loaded rod which shows reservoir content by index marks (full and refill) on the rod.

A relief valve (J) is mounted in the head (F). It is connected to the barrel (C) through an external relief valve vent line (B). If the reservoir is overserviced, the reservoir piston (D) will push against the relief valve (J) and open it. This allows the excess fluid to drain out through the overboard vent (K). This valve can also be pulled out manually. This permits the relief valve (J) to be used for draining and bleeding operation.

Exercises (402):

1. What are the two main reasons for pressurizing a reservoir?



- A. Filler valve
- B. Relief valve vent line
- C. Barrel
- D. Reservoir piston
- E. Piston spring
- F. Head
- G. Indicator rod
- H. System pressure line

- J. Relief valve
- K. Overboard vent
- L. Pressurization piston
- M. Overboard drain
- N. Pump supply line
- O. System return line
- P. Filter

Figure 1-5. Hydraulic pressure pressurized reservoir.

2. What are some of the consequences of not having a reservoir pressurized?
3. Why is reservoir pressure higher when system pressure is available?
4. How is the reservoir serviced with fluid?
5. What does the indicator rod's being at the refill mark indicate?
6. To prevent damage to the reservoir during servicing, what is provided?
7. What can be done to bleed air from the reservoir?

8. What unit in the reservoir pressurizes the hydraulic fluid to 5 psi?

403. Specify the function and sequence of air flow of an air pressurized reservoir system.

Air Pressurized Reservoirs. Figure 1-6 shows a reservoir that is pressurized by engine bleed air. Notice that this reservoir has a sight gage (I), which is made from glass or plastic to show the fluid level inside the reservoir. The filler cap (B), which is used to service the reservoir, has a pushbutton valve on top. This valve (A), commonly called a reservoir depressurization valve, is used for dumping the reservoir of air pressure before any servicing or maintenance is performed. Under the filler cap is a finger screen (C), which prevents dirt and other contaminants from entering the reservoir during servicing. This particular reservoir has four ports: air pressure (D), return (E), suction or supply (G), and a drain. The drain port in this case has a plug (H) installed. The drain plug is used to drain the fluid from the reservoir during maintenance. Inside the reservoir are baffle plates (F) that separate the suction line from the return line. The baffle plates cause the return fluid to circulate around the outer wall for cooling before it can go out the suction line to the pump again. The lower corners of the baffles are diagonally cut to allow the fluid to circulate and to let the fluid from the outer side of the baffles enter the suction port if the fluid level gets too low. Baffling also prevents the fluid from sloshing around when the aircraft is flying. Notice that the air pressure entering the air pressure port (D) pushes down on the fluid. This forces the fluid in the reservoir to the pump by way of the suction part (G). Notice also that the fluid that is returning from the system must flow around and over the baffles plates before it can go out the suction port again.

Air Pressure Regulator. The air pressure used in pressurizing hydraulic reservoirs must be controlled within safe limits. Specific pressure requirements vary between aircraft. Refer to figure 1-7. This regulator normally maintains 40 psi in the reservoir. It also incorporates a relief valve to relieve excessive pressure, and a differential valve to allow equalization of pressures between ambient (outside) air and the reservoir air pressure.

When air pressure at the outlet port is below 40 psi, the large spring under the diaphragm pushes the relief valve seat upward. It contacts the shaft and pushes the shaft up, thereby compressing the shaft spring, which unseats the shaft from the valve body. This allows engine bleed air to enter the inlet port, go down past the shaft seat, and flow out to

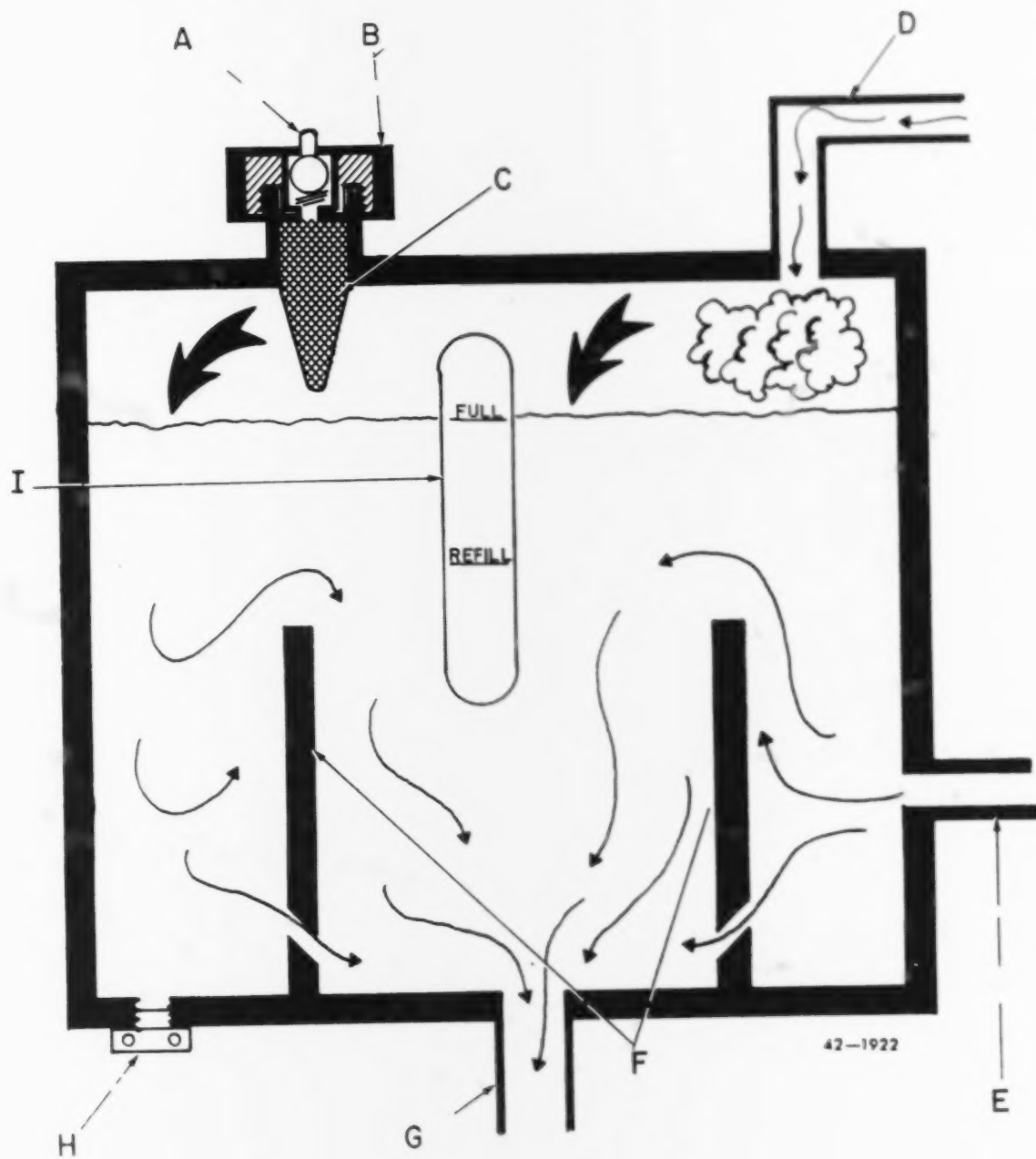
the reservoir during normal engine operation. When air pressure at the outlet port is at 40 psi, the air pressure pushes down on the diaphragm, compressing the large spring. The spring on top of the shaft then pushes the shaft down. This causes the shaft to go on seat with the body. As long as the reservoir maintains 40 psi, the valve will remain in this position.

When air pressure at the outlet port exceeds 45 psi, the pressure will push the diaphragm down, further compressing the large spring. The shaft can't go down any more because it is in contact with the body seat, so the relief valve goes off seat. This will vent the excessive reservoir air pressure through the relief vent port.

When air pressure at the outlet port falls below atmospheric pressure due to the loss of engine bleed air, the diaphragm will be pushed up by the large spring and atmospheric pressure until it contacts the body of the valve. As the pressure differential between the reservoir and atmospheric pressure reaches 2 psid, the differential (puppet) valves will be forced off seat (opened). This will allow atmospheric pressure to flow through two passageways, past the differential valve, and into the reservoir to equalize reservoir pressure with atmospheric pressure. This valve works like the radiator cap on your car.

Airflow Sequence. Refer to figure 1-8 as we trace the flow of air from the jet engine to the reservoir. The sequence starts at the engine air inlet (A). Here atmospheric air is drawn in by the rotation of the engine compressors (B and C). The two compressors increase the pressure and temperature of the air. Some of the air from the 16th stage of compression goes to the engine's combustion section (D), turbine section (E) and exhaust section (F). A tap off on the 16th stage of compression removes some of the compressed air for use in a number of other systems. Hydraulic reservoir pressurization is one of these systems.

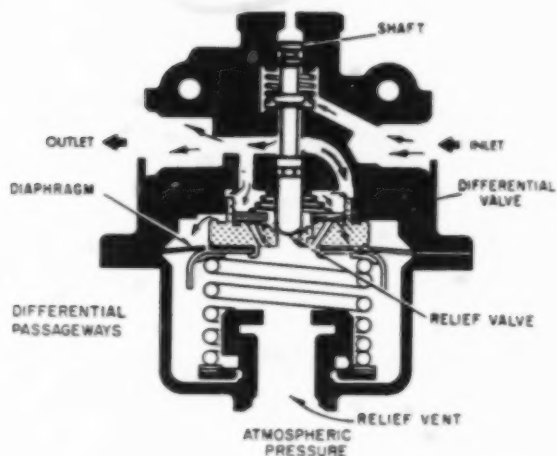
As you can see in figure 1-8, the first unit of the engine bleed air tap off is a heat exchanger (M). This unit removes the heat of compression from the bleed air by transferring this heat energy to atmospheric air. The bleed air now enters the reservoir pressurization system through a filter (G) and a flapper check valve (H). The air now flows to a pressure regulator (J) that controls the amount of air pressure going to the reservoir regardless of aircraft altitude. When the reservoir is unpressurized, the regulator lets ambient air into the reservoir through a filter (I). The filter prevents dirt from entering the reservoir. After passing through the regulator, the pressurized air enters the top of the reservoir (K). A reservoir depressurization valve (L) is in the line of the reservoir.



- A. Depressurization (dump) valve
- B. Filler cap
- C. Finger screen
- D. Air pressure port
- E. Return port

- F. Baffle plates
- G. Suction (supply) port
- H. Drain port (with plug)
- I. Sight gage

Figure 1-6. Air pressurized reservoir.

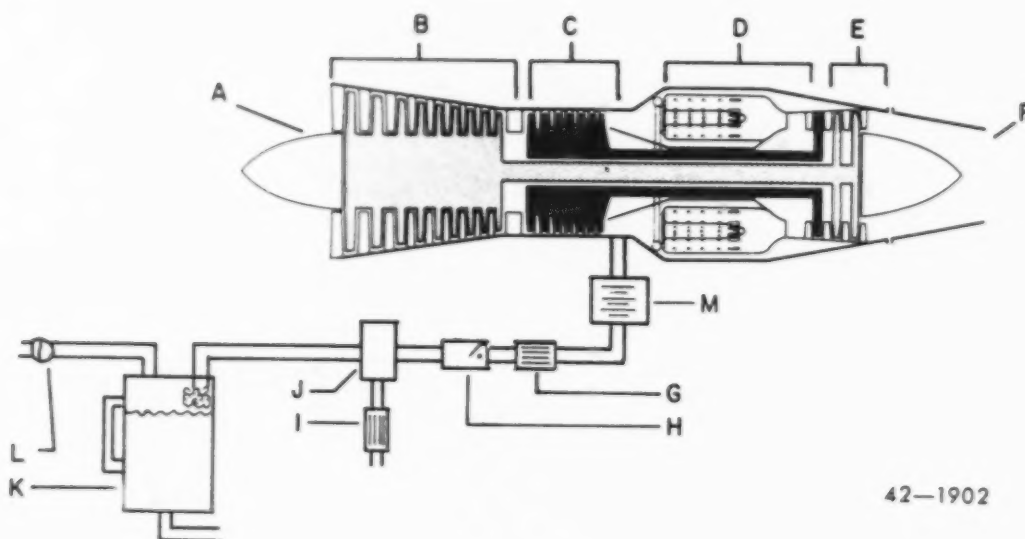


42-1887

Figure 1-7. Reservoir air pressure regulator.

Exercises (403):

1. Name three functions of the pressure regulator discussed in this objective.
2. If pressure rises too high in the reservoir, what will happen?
3. When the reservoir loses engine bleed air, what will happen?
4. Where is the air for reservoir pressurization usually taken from?
5. What does the check valve in the system do?
6. In order to service this reservoir or perform maintenance, what is the first thing you should do?



42-1902

- A. Engine air inlet
- B. Engine compressor (low-pressure)
- C. Engine compressor (high-pressure)
- D. Combustion section
- E. Turbine section
- F. Exhaust section
- G. Engine bleed filter

- H. Flapper check valve
- I. Atmospheric vent filter
- J. Air pressure regulator
- K. Reservoir
- L. Depressurization (dump) valve
- M. Heat exchanger

Figure 1-8. Reservoir pressurization airflow.

1-2. Hydraulic Pumps

Like the human heart, the hydraulic pump is the unit that normally delivers fluid flow under pressure into the system. The pump does this by converting mechanical energy (engine, motor, or turbine) into a fluid flow. Notice that we say "fluid flow" instead of "pressure." The pump produces a fluid flow and resistance to this flow creates the pressure. Pumps are classified by their displacement (volume) output. There are positive displacement (constant volume) pumps and variable displacement (variable volume) pumps. Displacement is the amount of fluid the pump will produce on each cycle or revolution. The main difference between the constant and variable volume pumps is in the regulating devices needed. The constant volume pump needs some type of external regulating device, while the variable volume pump has a built-in regulating device.

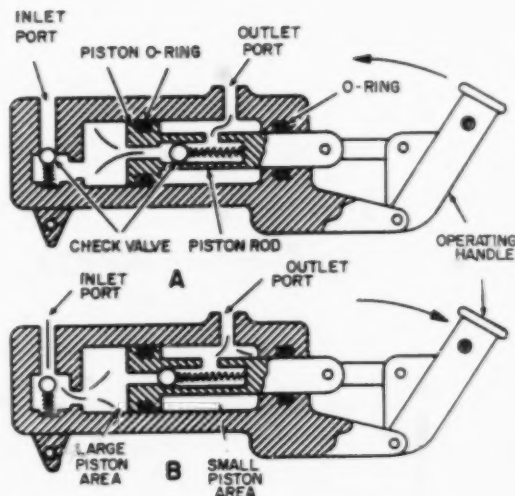
404. Using figure 1-9, specify hand pump operation; and, from symptoms given, name the check valve that has malfunctioned.

Hand pump. The hand pump shown in figure 1-9 serves two purposes. It can be used as an emergency source of pressure or as an auxiliary source of pressure for ground checking the operation of the system units. The hand pump we will discuss is a reciprocating piston pump that is double-acting. This type delivers fluid under pressure on both the retraction stroke and extension stroke of the piston. This unit consists of an inlet port, inlet check valve, piston, piston check valve, large piston area, outlet port, and small piston area. Notice that the piston separates the large piston area from the small piston area.

When the piston moves to the right (extension stroke, fig. 1-9,B), the check valve in the piston is held closed by the spring. The piston forces the fluid in the small piston area out through the pressure port and into the system. At the same time, the suction effect of the moving piston draws fluid through the inlet check valve. This fills the large piston area (E) with fluid.

When the piston is moved to the left (retraction stroke, fig. 1-9,A), the inlet check valve is held closed by the pressure of the fluid in the large piston area and the spring. As the piston continues to move, it forces the piston check valve to go off seat, letting fluid turn into the small piston area. The piston rod causes less space to be available for the fluid in the small piston area; therefore, the excess fluid under pressure is given out through the outlet port and into the system.

Every piece of equipment, no matter how simple, can malfunction. The hand pump is no exception. However, since it is only operated at short



42-1894

Figure 1-9. Hand pump (double acting).

intervals, malfunctions do not occur too often. They can happen, though, and you can determine the cause if you understand its operation.

Failure of either check valve will cause the hand pump to become completely inoperative. However, installing a third check valve in the pressure (to system) line will allow pressure to build up on at least one stroke if one of the check valves (inlet or piston) were to fail. This third check valve (not shown) prevents normal system pressure from reaching the hand pump during normal system operation. It will also aid the mechanic in determining hand pump failure. As an example, if the inlet check valve in the inlet port leaks, the pump will develop pressure only on the piston "extension" stroke. If the piston check valve in the piston rod or the piston seal leaks, the pump will develop pressure only on the piston "retraction" stroke. If the third check valve located in the system pressure line (not shown) were to leak, there will be no immediate indication of it. In this case the pump will still develop pressure on both strokes until one of the other check valves malfunction, then the hand pump will be completely inoperative. The thing to remember is that, in order to produce fluid flow from this pump, you must have at least two check valves operating.

Exercises (404):

Figure 1-9 can be used to answer the following questions.

1. When the hand pump handle is on the extension stroke, which check valve is on seat?

2. When the hand pump handle is on the retraction stroke, which check valve is on seat?
3. If either check valve inside the hand pump malfunctions, what would be the indication?
4. If a third check valve is installed, what could be the problem if fluid is only sent into the system on the extension stroke?
5. In order for the double-acting hand pump to operate, how many check valves must be operational?
6. When the hand pump is on the retraction stroke, how is fluid being pumped into the system?
7. What happens to the fluid in the large piston area when the pump is on the retraction stroke?

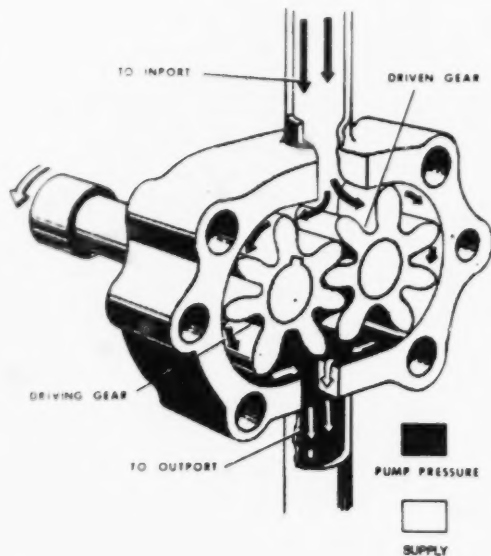
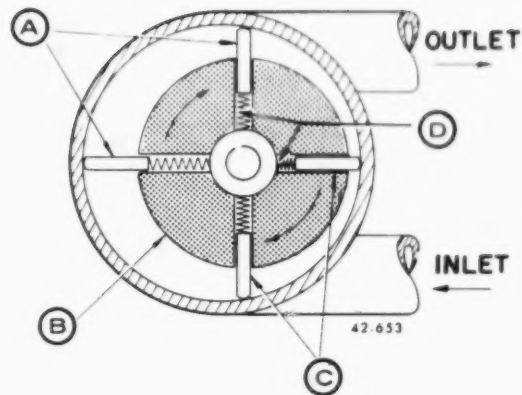


Figure 1-10. Gear pump.



- | | |
|------------------|------------------|
| A. Sliding vanes | C. Sliding vanes |
| B. Rotor | D. Springs |

Figure 1-11. Vane pump.

405. Indicate whether given statements correctly reflect the constructional and operational features of constant volume pumps.

Constant Volume Pumps. A constant volume pump sends a fixed amount of fluid out the discharge port for each pump revolution. For example, if a pump produces 1 gallon of fluid at 1000 revolutions per minute (rpm), then at 3000 rpm the pump should produce 3 gallons per minute. There is one drawback to this type of pump, especially if the output is directed into a confined area. As long as the pump rotates, the fluid flow it produces will eventually build up a high enough pressure in the confined area to burst the lines and container. To insure that this doesn't happen, some sort of regulating device will have to be installed. Some of the regulating devices used are pressure regulators, pressure switches, and relief valves. These components will all be explained in the following chapters of this volume. For now let's look at the three types of constant volume pumps: gear, vane, and piston.

Gear pump. A gear pump consists of two meshed gears which revolve in a housing. (See fig. 1-10.) The drive gear is turned by a drive shaft. The drive shaft of most pumps have a shear section. The shear section is a thinned portion of the drive shaft that prevents damage to the driving unit (engine, motor, turbine) by breaking at the thinned section if the pump seizes. The clearance between the gear teeth as they mesh and between the teeth and pump housing is very small. The inlet port is connected to the reservoir line, and the outlet port is connected to the pressure line. In figure 1-10, the drive gear is turning in a counterclockwise direction, and the

driven (idle) gear is turning in a clockwise direction. As the teeth pass the inlet port, fluid is trapped between the teeth and the housing. This fluid is carried around the housing to the outlet port. As the teeth mesh again, the fluid between the teeth is displaced into the outlet port. This action produces a positive flow of fluid under pressure into the pressure line.

Vane pump. A simple schematic of the vane pump is shown in figure 1-11. This particular pump has four sliding vanes (A and C) mounted in an eccentric (off-center) motor (B). The housing consists of an inlet port and outlet port. The springs (D) behind each vane forces the vane out against the housing. The rotor is mounted off-center in the housing. As the vanes rotate, the space (volume) between the vanes increases during the first half-turn. This draws fluid into the pump. During the last half-turn of rotation, the space (volume) between the vanes decreases and fluid is forced out of the pump under pressure. Pumps of this type are usually used in low pressure systems.

Constant-volume piston pumps. The pistons, usually seven or nine in number, are fastened by universal linkage to the drive shaft. (See fig. 1-12.) The universal link (B) in the center drives the cylinder block (D). This block is held at an angle to the drive shaft (A) by the housing. Everything within the housing rotates with the drive shaft. As the piston (J) moves to the lower position, its cylinder fills with fluid. When it rotates to the upper position (E), its movement will force fluid

out of the pressure port (G). As it again moves to the lower position, it again draws in fluid through the suction port (H). Since there are always pistons somewhere between the upper and lower position, constant intake and output of fluid results. Pumps are available with different angles between the drive shaft and cylinder block; a large angle provides more volume output per revolution because the larger angle increases the piston stroke.

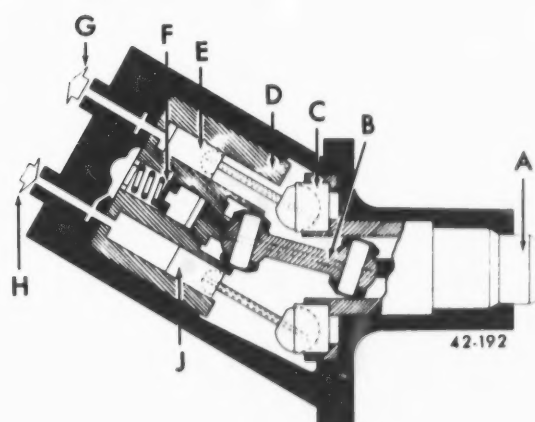
As the drive shaft (A) is rotated, it rotates the cylinder block (D) and piston assemblies. Notice that all pistons are always the same distance from their points of attachments (C) on the drive shaft. Although the pistons appear to move within the cylinders, it is the cylinders that move back and forth around the pistons as the block and piston assembly rotates. However, it is customary for a piston to move within a cylinder. Since this appears to be happening, we will describe the pumping action of the pump in these terms.

To understand the operation, follow a piston through one complete revolution. The piston (E) is at the top of its cylinder. It has just completed its pressure stroke and is ready to begin its intake stroke. As the block starts to rotate from this point, the piston becomes aligned with the intake port. When the block has turned one-half of a revolution, the piston reaches the bottom of the cylinder. The cylinder space formerly occupied by the piston is now full of fluid.

As the block continues to rotate, the piston becomes aligned with the outlet port slot. Thus, when it has moved through the last 180° of rotation, it exhausts all fluid from the cylinder. At this point, the piston is again ready to make another cycle. There are several pistons operating as described above. The cylinder block and piston assembly rotate rapidly. Therefore, there will always be a positive flow of fluid through the outlet port.

The piston pump uses case pressure for cooling and lubrication. Fluid seeps by the pistons in the cylinder block and fills all the space inside the pump. This fluid cannot escape through the drive end of the pump because of a seal placed around the drive shaft. Excess case pressure within the housing is routed back to the intake side of the pump. This is done through a relief valve called a foot valve. This valve prevents the case pressure from rising above approximately 15 psi. Notice the drilled passageways through the universal link rods. These help to keep the rod ball ends lubricated.

Figure 1-12 shows the foot valve (F) located inside the bearing around which the cylinder block rotates. Other models have the valve in the head, together with the intake and outlet ports. Some of the newer models have two foot valves, both located in the head. The direction the accessory drive rotates determines the direction of pump action. An arrow on the pump head indicates the



- | | |
|------------------------|---------------------------|
| A. Drive shaft | F. Foot valve |
| B. Universal link | G. Pressure (outlet) port |
| C. Point of attachment | H. Suction (intake) port |
| D. Cylinder block | J. Piston |
| E. Piston | |

Figure 1-12. Constant volume piston pump.

direction of rotation for which the pump is set up.

The direction of rotation of piston-type pump with one foot valve can be reversed. To do so, remove the cylinder block head, rotate the valve plate 180°, and reinstall. Leave the suction and pressure attachments as they were. This, in effect, reverses the intake and outlet port slots (G and H of fig. 1-12). For the models with two foot valves, it is not necessary to rotate the head. Simply interchange the suction and pressure line connections.

The power pumps discussed thus far have been the constant-displacement type; that is, for any given rpm, the volume output is constant. However, the other version of the piston pump is the variable-volume type.

Exercises (405):

Indicate if the following statements correctly reflect the constructional and operational features of constant volume pumps by placing in the blank a T if it is true and an F if it is false. Correct the false statements.

- 1. Constant volume pumps need a separate regulating device.
- 2. The two gears in the gear type pump are the drive and driven gear.
- 3. The driven gear is attached to the drive shaft.
- 4. If the drive gear is turning counterclockwise, the driven gear will be turning clockwise.
- 5. The gear pump has two sliding vanes.
- 6. The vane pump has an eccentric rotor.
- 7. The vanes of the vane pump are stationary.

- 8. Drive shaft cylinder block, pistons, and universal link all rotate within the cylinder block of the constant volume piston pump.
- 9. The larger the angle between the drive shaft and cylinder block, the less the fluid flow.
- 10. The piston pump uses case pressure for cooling and lubrication.
- 11. Excess case pressure is routed through the shaft seal, then to return.
- 12. To reverse the direction of rotation of a piston pump with two foot valves, you should rotate the head 180°.

406. Indicate whether given statements correctly reflect the constructional and operational features of variable volume pumps.

Variable-Volume Pumps. The variable-volume pump has some advantages over the constant volume pump. One is that its use does away with the need for a separate pressure regulating device. An integral flow control valve (compensator) regulates the pressure according to the demands made by the system. A second advantage is that this type pump provides a more stable pressure by reducing pressure surges. We will discuss three types of variable volume pumps: Vickers, Kellogg, and Stratopower.

Vickers stroke-reduction pump. This type of pump has many parts similar to the constant volume piston-type pump. The main difference between this pump and the constant volume pump is the angle between the drive shaft and the cylinder block. In the constant volume pump, this angle is fixed, but the angle in the variable-volume pump varies automatically. Its angle depends upon the pressure-volume demands of the system. The drive shaft, pistons, and cylinder block all rotate in the stroke-reduction pump. (See fig. 1-13.) They are supported by the bearing.

The yoke contains the cylinder block, which swivels around a pivot. The pivot is hollow and is designed to provide a passage for the pump's inlet and outlet fluid.

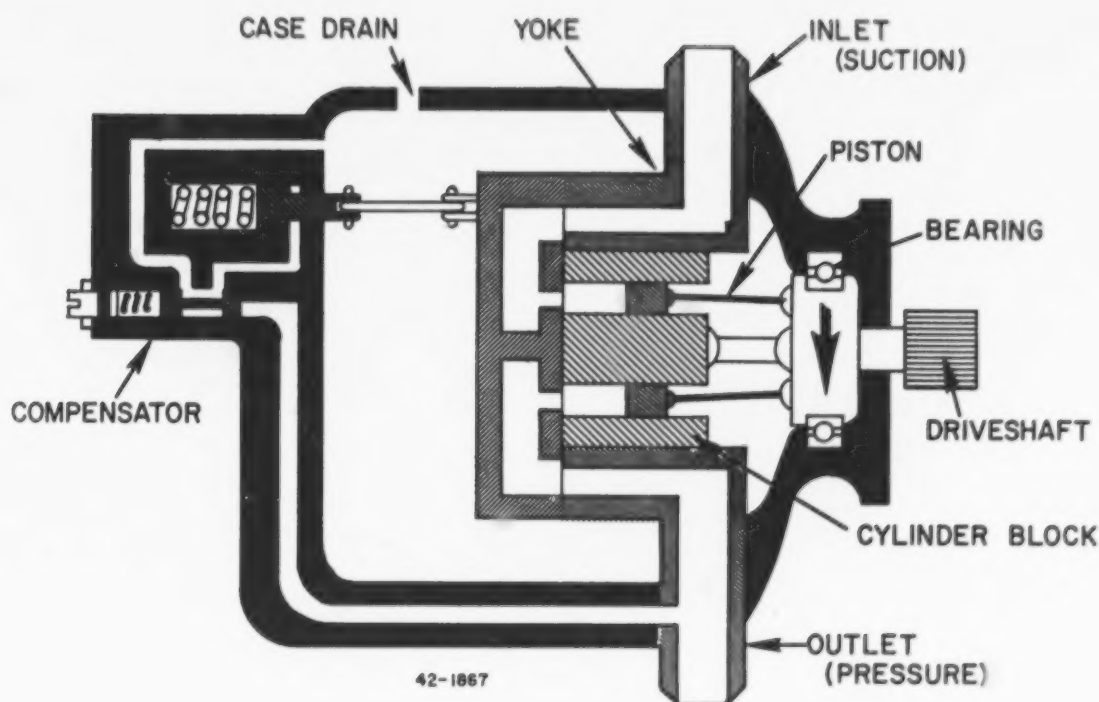


Figure 1-13. Vickers stroke-reduction pump (top view).

A passageway from the pressure outlet port routes fluid under pressure to the compensator. The compensator assembly consists of the compensator piston, compensator spring, adjusting screw, control piston, and control piston spring. The control piston is attached to the mechanical link, which is attached to the yoke assembly. Follow along as we discuss the pump's operation.

We start with zero pressure in the system. The cylinder block and yoke are in the extreme angle position, as shown in figure 1-14, FULL FLOW. As the pump builds up system pressure through the outlet port, it acts on the pressure compensator. System pressure entering the connecting line acts on the compensator piston. It pushes this piston against spring tension. When pressure in the pump connecting line overcomes spring tension, it sends pressure against the rod side of the control piston. As the piston moves to the left, it compresses its spring. This force, transmitted through the mechanical link, causes the yoke to swivel upward. The cylinder block moves toward a zero angle with the drive shaft. If it reaches the extreme ZERO FLOW point, as shown in figure 1-15, the fluid output from the pressure port is zero. The reason for this is that the pump pistons have no stroke in the cylinder block; they simply rotate with the cylinder block without moving back and forth.

As the pressure in the system starts to drop, its force on the compensator piston is reduced. (See fig. 1-14.) When this happens, the spring under the compensator piston moves it to the right. This closes the passageway to the pressure control piston and opens the passageway from the pressure control piston to return. The control piston spring then pushes this piston to the right. Now the yoke swivels downward, thereby causing the stroke of the pistons to increase. The pressure and volume output again start to increase until the system's demands are met. Thus, the action of the compensator stabilizes the position of the cylinder block by adjusting its angle to meet the system's demands. The pressure needed is obtained by turning the adjusting screw either to increase or decrease. The direction of rotation of this pump cannot be changed; therefore, you must be sure to check the direction arrow on the mounting flange before you install it.

Kellogg stroke-reduction pump. Figure 1-16 shows a schematic of the Kellogg pump. The pump is made up of two major component groups: the rotating group and the pressure-compensating group. The rotating group consists of the drive shaft (D), the cylinder barrel (B), nine pistons, and the piston shoes (C). The pressure-compensating group consists of a compensator piston (E),

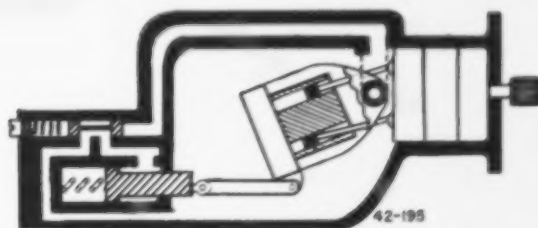


Figure 1-14. Vickers stroke-reduction pump (full flow).

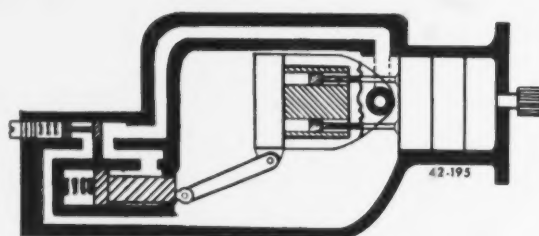
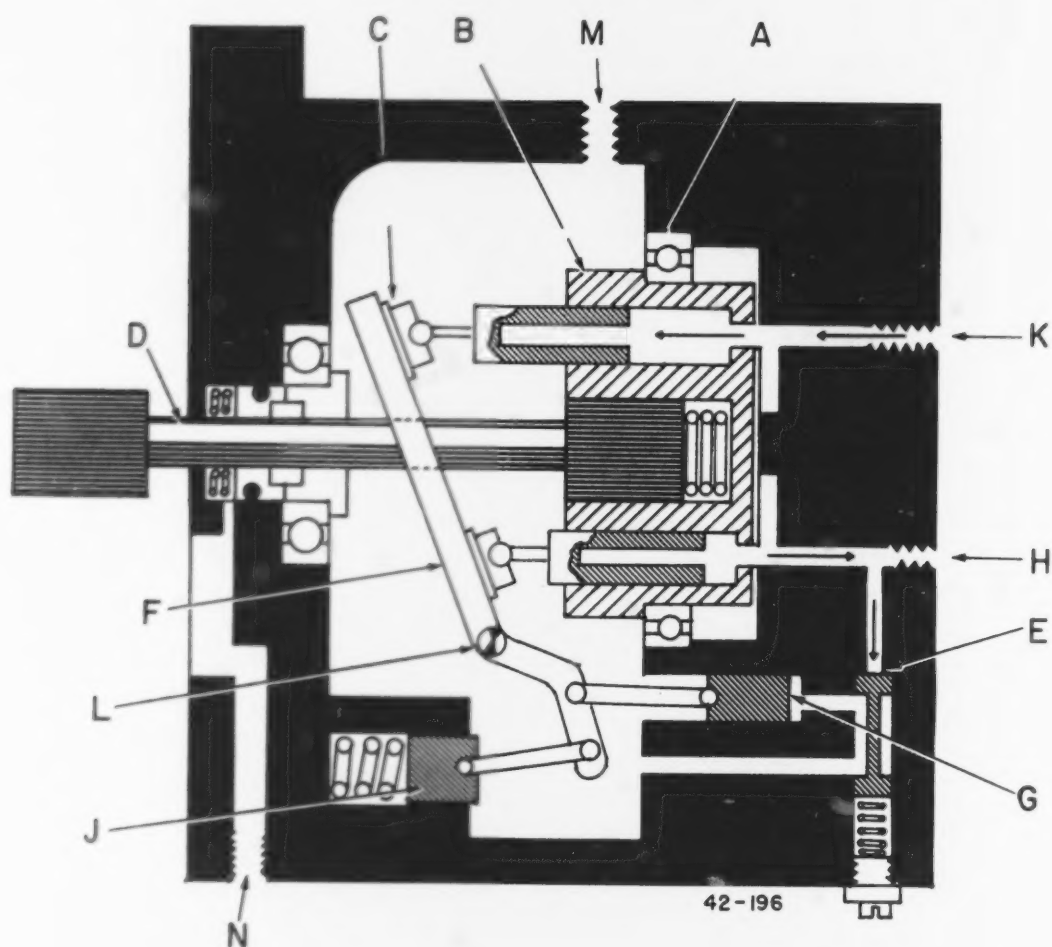


Figure 1-15. Vickers stroke-reduction pump (zero flow).



- A. Bearing
- B. Cylinder barrel
- C. Piston shoe
- D. Drive shaft
- E. Compensator piston
- F. Cam plate
- G. Stroking piston

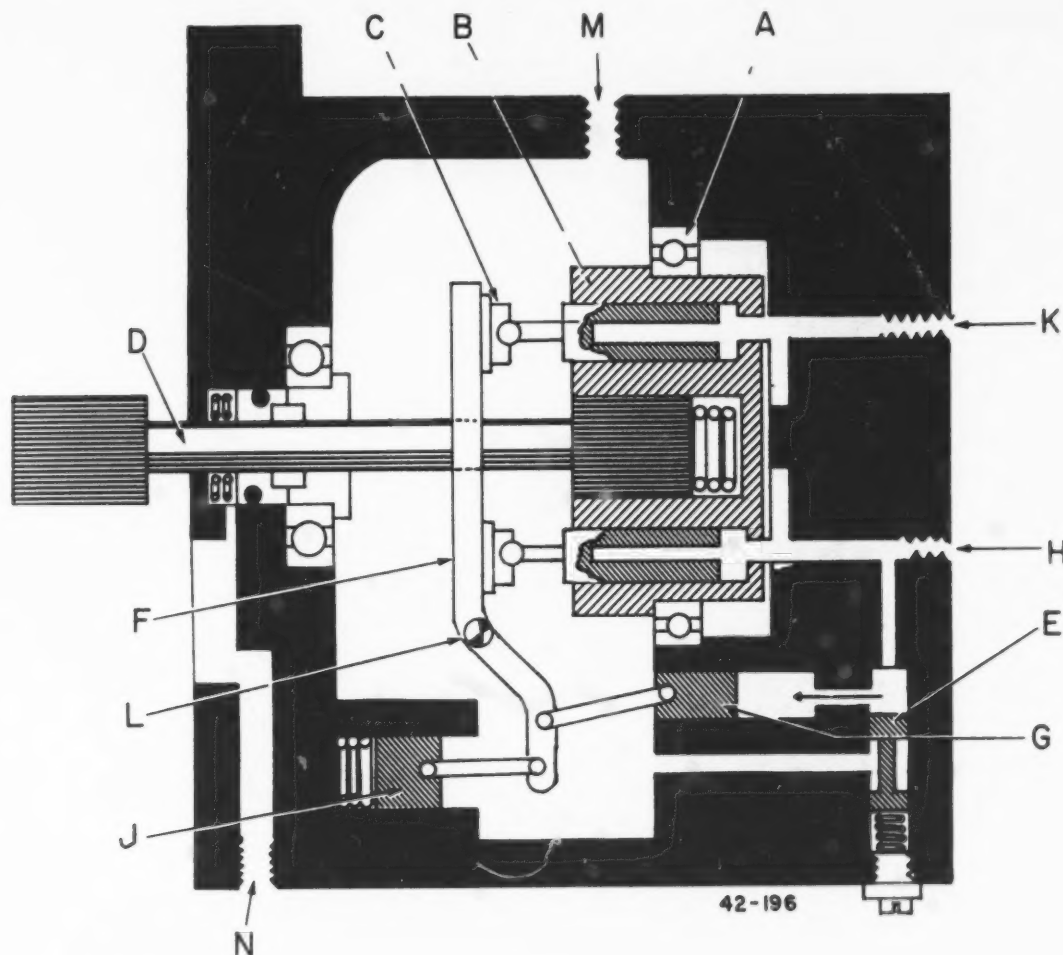
- H. Outlet port
- J. Rate piston
- K. Inlet port
- L. Pivot pin
- M. Case drain
- N. Shaft seal drain

Figure 1-16. Kellogg stroke-reduction pump (full flow).

stroking piston (G), rate piston (J) and cam plate (F). The cam plate is attached to the pump by the trunnion pivot pin (L), rate piston (J), and stroking piston (G).

The cylinder barrel (B) has a fluid inlet annulus (slot) in its face to supply the cylinders. It is long enough to serve during the intake portion of one revolution. An outlet annulus serves the discharge portion of one revolution. The barrel is supported in the housing by a roller bearing (A). The drive shaft (D) passes through, but does not touch the inclined cam plate (F) to rotate the cylinder barrel

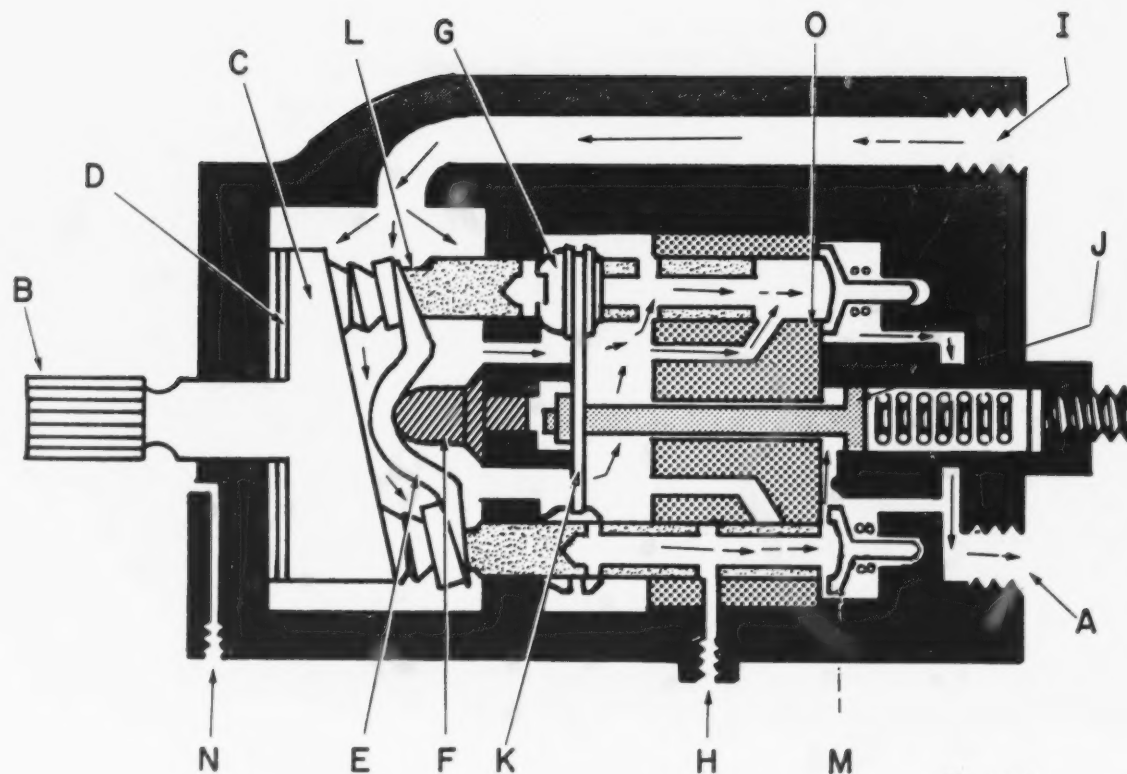
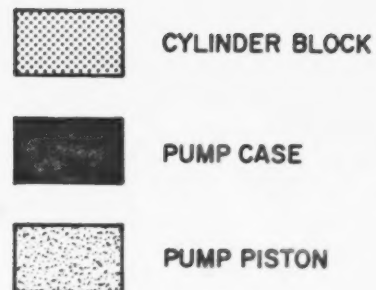
(B) unit. Pistons of the rotating group are actuated by tilting the nonrotating cam plate (F). The hydraulically balanced shoes (C) are attached to the pistons by a universal joint. The length of the piston stroke is determined by the angle setting of the cam plate. Full pump output requires a high angle; zero pump output requires a flat angle setting. The rate piston (J) spring forces the cam plate (F) to a full flow position. The stroking piston (G), on the other hand, will place the cam plate to a zero flow position when the desired pressure is reached.



- A. Bearing
- B. Cylinder barrel
- C. Piston shoe
- D. Drive shaft
- E. Compensator piston
- F. Cam plate
- G. Stroking piston

- H. Outlet port
- J. Rate piston
- K. Inlet port
- L. Pivot pin
- M. Case drain
- N. Shaft seal drain

Figure 1-17. Kellogg stroke-reduction pump (zero flow).



42-1884

- | | |
|-------------------------|-------------------------|
| A. Pressure port | I. Inlet (suction) port |
| B. Drive shaft | J. Compensator piston |
| C. Cam | K. Spider |
| D. Creep plates | L. Piston |
| E. Nutating plate | M. Check valve |
| F. Nutating plate pivot | N. Shaft seal drain |
| G. Sleeve | O. Cylinder block |
| H. Case drain port | |

Figure 1-18. Stratopower pump (demand principle) (full flow).

The upper piston in figure 1-16 is shown near the end of the intake stroke. The face port of this cylinder is aligned with the fluid inlet port (K) for nearly one-half of a revolution. Hydraulic fluid is sucked into the cylinder as the piston is withdrawn. Further rotation forces the piston to the right. The cylinder will then be aligned with the outlet annulus during the discharge stroke. This stroke lasts until the cylinder and piston reach the bottom position in figure 1-16. The outlet annulus is connected to the outlet port (H) and the compensator valve.

We have described the intake and discharge strokes of one piston during 360° of cylinder rotation. At the same time, there are eight other pistons on the intake and discharge strokes, all doing the same thing. Their pumping action continues until the fluid needs of the system are satisfied. For instance, when a subsystem actuator completes its travel, the need for pump output is reduced to zero. The pump senses the end of the actuator travel because the unused output causes a sudden increase in discharge pressure. As this pressure reaches the setting of the compensator piston (E), it pushes the valve down. (See fig. 1-17.) The pressure then can push on to the stroking piston (G). There it causes the stroking piston to move to the left, thereby decreasing the angle of the cam plate (F). Thus, it decreases the effective length of the piston stroke and the volume of fluid delivered to the system. In actual operation, the cam plate assumes various angles to maintain the

system's proper pressure. It will meet all fluid demand conditions within the rating of the pump.

Stratopower pumps (demand principle). As shown in figure 1-18, the drive shaft (B) rotates the cam (C). This cam causes the nine pistons (L) to move back and forth in their cylinders. The cylinders are in a stationary cylinder block (O). Creep plates (D) on the back side of the cam provide for cooler operation. (The creep plates look like washers in fig. 1-18.) They also give more even wear on the cam. In operation, each piston is compressed into and released from the cylinder, once for each revolution of the cam. The pistons are held in contact with the creep plate by the nutating plate (E) and nutating plate pivot (F). Each piston has a half-ball bearing surface which acts like a universal linkage. The flat side contacts the cam plate during all angle changes.

The pistons (L) have fairly large hollow centers connected with cross-drilled holes. Each piston has a sleeve (G) around it. The sleeves are attached to a spider (K); the spider is attached to the compensator piston (J). An increase of pressure moves the compensator piston (J) to the right. A decrease of pressure allows it to move to the left because of the valve spring tension. As the pistons travel to the left (see the top piston in Fig. 1-18), fluid is drawn from the "in" port (I). It passes through the open center of the cylinder block (O), then into the pistons (L). At this point, hydraulic fluid will fill the center of the pistons. As the

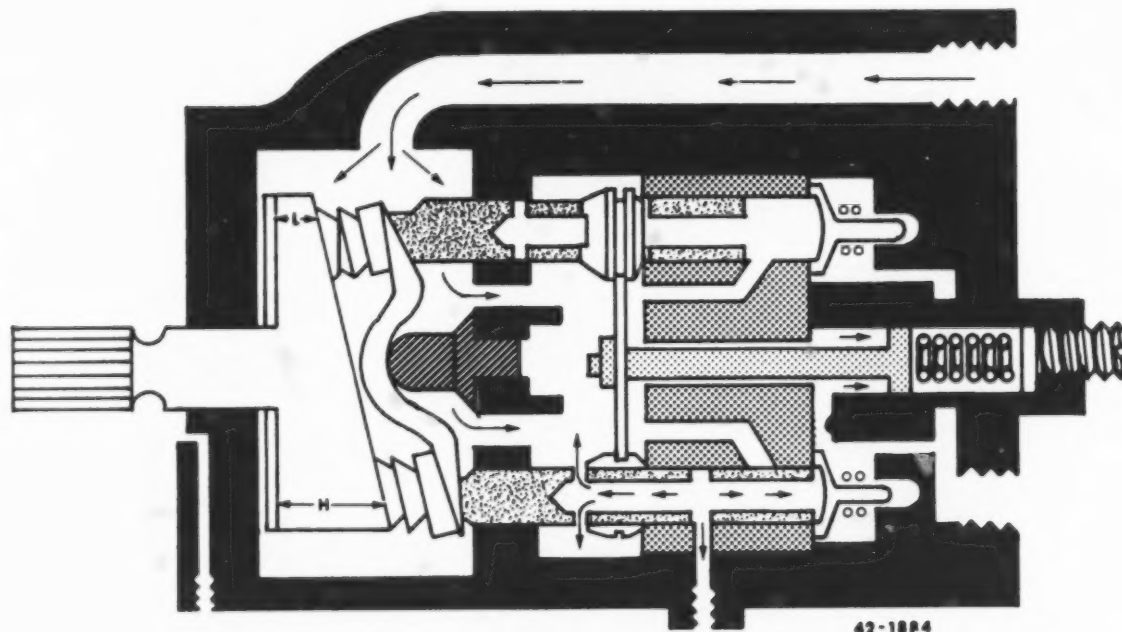


Figure 1-19. Stratopower pump (demand principle) (zero flow).

pistons are forced to the right by the cam, the left drilled passageway of each piston is blocked off by its sleeve. (See the bottom piston in fig. 1-18.)

About the time the left drilled passageway is blocked off, the right drilled passageway is blocked by the cylinder block. This, in turn, traps the fluid in the piston and cylinder. As the piston continues on to the right, pressure builds up against the check valve. Fluid under pressure goes out the check valve and through the pressure port (A). When the piston moves as far right as possible, the cycle starts all over again.

This cycle is the same for all nine pistons. As pressure rises in the pressure outlet line, it is also felt on the compensator (fig. 1-19). This pressure acts on the compensator piston, forcing it to the right. This compresses the spring and carries the spider and sleeves with it. The more the sleeves move to the right, the farther each piston will travel before the drilled passageways are covered. Less fluid will now be trapped by the right end of the piston for output to the pressure manifold. This also means that, because the drilled passageways are uncovered, fluid will circulate through the pump. This will drop the output to the pressure manifold to zero. A small amount of fluid will be pumped out the case drain port for cooling and lubrication each time the piston is pushed almost all the way into the cylinder barrel. This can be seen by the bottom piston in figure 1-19. There is always fluid being pumped through the suction port. But fluid will not be pumped through the pressure port until system pressure drops low enough to demand it.

This pump can be rotated in either direction with no changes. Always connect the proper lines to the ports. Adjustment of maximum pressure can be made by turning the adjusting screw. Turning the screw clockwise increases the pressure, and turning the screw counterclockwise decreases the pressure.

Exercises (406):

Indicate whether each of the following statements correctly reflect the constructional and operational features of the variable volume pumps by placing in the blank space a T for a true statement or an F for a false statement. Correct the false statements.

- _____ 1. Variable volume pumps have integral control valves.
- _____ 2. The two types of stroke reduction pumps are Vickers and Kellogg.
- _____ 3. Variable volume pumps produce violent pressure surges.

- _____ 4. The term zero flow indicates that no fluid is being pumped into the system.
- _____ 5. The yoke on the Vickers stroke-reduction pump pivots from full flow to zero flow.
- _____ 6. The compensator on variable volume pumps adjusts to increase or decrease pressure.
- _____ 7. The yoke pivots in the Kellogg pump.
- _____ 8. The cam, yoke, and pistons all rotate in the Kellogg pump.
- _____ 9. The stratopower pump can be rotated in either direction.
- _____ 10. The stroking piston places the cam plate of the Kellogg pump to the full flow position.
- _____ 11. The sleeves in the stratopower pump are actuated by the cam plate.
- _____ 12. A small amount of fluid is routed to return through the case drain line for cooling and lubrication in the stratopower pump.
- _____ 13. When the stratopower pump is in the zero flow position, the holes in the pistons are uncovered by the sleeves.
- _____ 14. The sleeves in the stratopower pump are positioned by the stroking piston.
- _____ 15. Leakage around the drive shaft of a pump will go to return through the case drain line.

Hydraulic and Pneumatic Power System Components

IN CHAPTER 1, we talked about the components that stored hydraulic fluid and pumped it out into the system. This fluid must be controlled and directed to its point of use. As it flows, it can become dirty and increase in temperature. This chapter will discuss the components used to control, clean, and cool the fluid.

This chapter is broken down into three sections. Each section covers items of a particular nature. The first section deals with valves and the second section deals with filters, coolers, and accumulators. The third section will cover the units found in the power section of most pneumatic systems.

2-1. Power System Valves

Each valve we will discuss is quite unique, but by its name alone you can just about figure out what it does. A shutoff valve naturally shuts off fluid, and a pressure regulator regulates pressure. In this section we will discuss check valves, shut-off valves, relief valves, and pressure regulators. They are used to direct, limit, shutoff, disconnect, connect, and even direct the flow of fluid in the system.

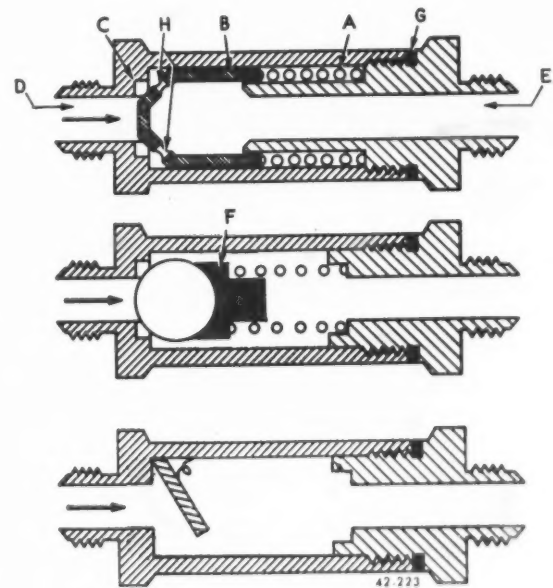
407. Specify the constructional and operational features of check valves.

Check Valves. Check valves are installed in pneumatic systems to allow flow in one direction and no flow in the other. There are so many different versions of check valves that we will only cover the two most common check valves used on aircraft, automatic and manual.

Automatic check valves. Typical examples of automatic check valves are shown in figure 2-1. Each automatic check valve contains a seat onto which a poppet (ball, cone, or flapper) will be forced by spring tension. The top illustration shows the cone check valve. As fluid pressure enters the inlet port (D), it overcomes the spring tension (A). The tension on each check valve is slightly different, but basically each one has a relatively weak spring, intended only to keep the poppet

against its seat. As the inlet pressure overcomes spring tension, it forces the cone (B) off the valve seat (C). This allows fluid to pass freely through the drilled openings (H) of the cone and through the outlet (E). As inlet pressure drops off, spring tension along with pressure in the outlet side of the check valve forces the cone back on seat. This is all done automatically.

The middle illustration shows a ball check valve. The operation and construction is basically the same as the cone type check valve. This valve has one other item, however, that is not found in the cone type check valve. It is the ball follower (F). Without the ball follower, the ball check valve



- | | |
|---------------|---------------------|
| A. Spring | E. Outlet port |
| B. Cone | F. Follower |
| C. Valve seat | G. Seal |
| D. Inlet port | H. Drilled openings |

Figure 2-1. Automatic check valve.

sometimes cocks to one side of the valve seat. This allows fluid to leak through the seat. The ball follower evenly distributes the spring tension against the ball.

The bottom illustration shows a flapper or gate type check valve. Here again this valve is basically the same as the cone type except that it has a flapper instead of a cone. This valve is primarily used in low pressure systems, such as the air pressurized reservoir system. Many hours of troubleshooting have been caused by installing this simple valve backwards, even though it is plainly marked.

When installing an automatic check valve, remember that the arrow marked on the housing must point in the direction of free flow of the fluid through the valve. (See fig. 2-2.)

Manually operated check valves. These check valves can be unseated manually to permit free flow of fluid in both directions. (See fig. 2-3.) This valve has two distinct operations. With the handle (D) in the closed position, this valve acts as an automatic check valve. When the handle is moved to the open position, the valve performs exactly like a straight tube and allows free flow in either direction. The top illustration of figure 2-3 shows the valve in the closed position. With the valve in this position, fluid can pass through the valve from the inlet port (C); it forces the poppet (B) off seat, compressing the spring (F). This allows the fluid to flow out the outlet port (A). As inlet pressure drops off, the spring forces the poppet (B) back on seat. If fluid tries to flow from the outlet port (A) to the inlet port (C), it can't because the poppet (B) is on seat. The bottom illustration shows the valve in the open position. In this position, the handle (D) has been turned so that the poppet is held off seat by the cam (E). This allows a free flow of fluid through the valve in both directions.

Frequently a manually operated check valve is installed in the pressure line leading to a subsystem so that pressure to that system can be shut off. Such an installation enables the maintenance man to work in specific areas without danger. Men have been killed by bomb doors which closed because proper safety precautions were not observed. This valve also permits the isolation of certain subsystems for troubleshooting.

Positioning and operating in a simple system. Follow along as we discuss the schematic

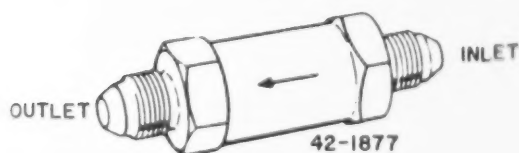
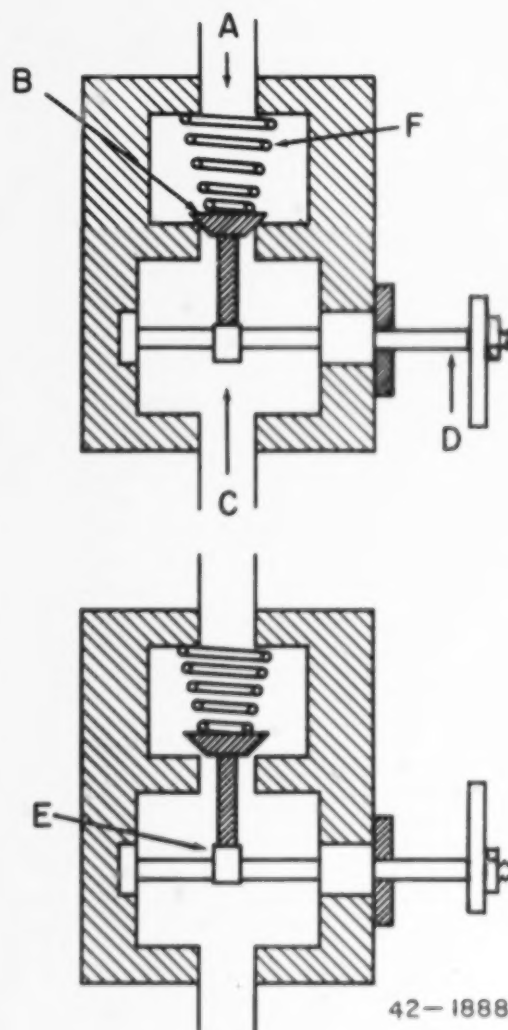


Figure 2-2. Check valve showing the direction of free flow.



- | | |
|----------------|-----------|
| A. Outlet port | D. Handle |
| B. Poppet | E. Cam |
| C. Inlet port | F. Spring |

Figure 2-3. Manually operated check valve.

in figure 2-4. This system has two pumps, one an engine-driven piston pump (D), and the other a motor-operated gear pump (E). Each pump is supplied with fluid from the same reservoir (A). In this case we will show two selector valves, let's say that one is for the bomb doors (I), and the other for the flaps (K). During flight the engine-driven pump (D) draws fluid from the reservoir (A). Fluid flows from the pump through the check valve (B), to the bomb door selector valve (I). Notice also that it flows through the check valve (H), through the normally open manually operated check valve (K), to the flap selector port valve (K). Even though the

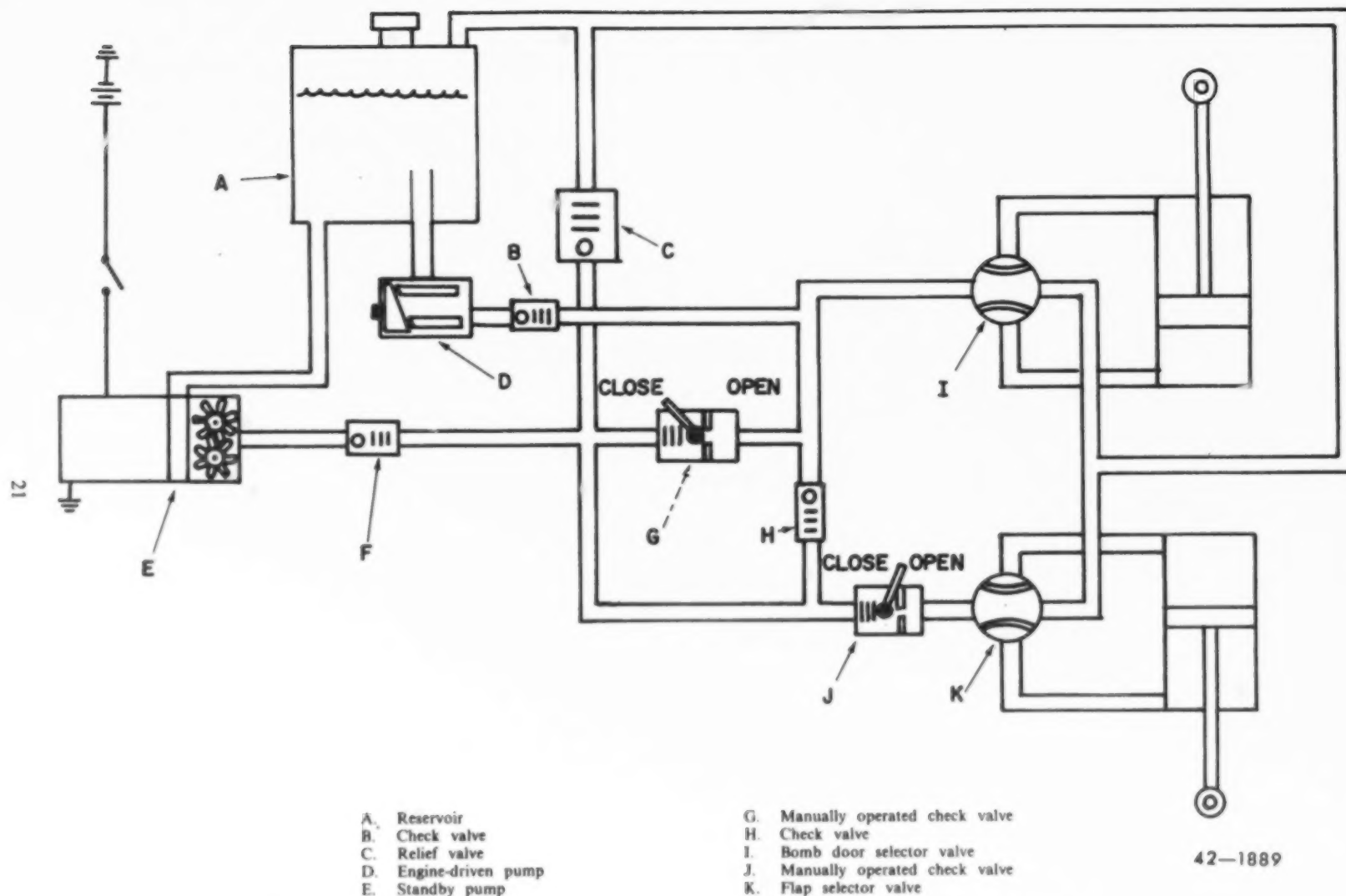


Figure 2-4. Simple hydraulic system with manual check valves.

manually operated check valve (G) is closed, fluid can flow freely to the main system relief valve (C). If the pressure rises too high, the relief valve will send excess pressure back to return. Check valve (F) prevents the pressure from the main system from reaching the standby pump (E). So you can see that, while the aircraft engines are running, the bomb doors and flaps can be operated by the engine-driven pump.

When the aircraft engines are shut down, there isn't any pressure available for operation of the various systems. If the systems must be operated while the engines are shut down, then the standby pump (E) must be turned on. Fluid from the pump will flow through the check valve (F), up to the relief valve (C), down to the manual check valve (J), and then to the flap selector valve (K). Notice that check valve (H) and normally closed manual check valve (G) prevent fluid from the standby pump from reaching the bomb door selector valve (I). This is actually a safety measure because it will prevent the bomb doors from accidentally being operated while hydraulic pressure is applied. In order to get fluid to the bomb door selector valve, the manual check valve (G) must be placed in the open position. This will allow the fluid from the standby pump to go directly to the bomb door selector valve.

The manual check valve (J) is normally in the open position. This allows fluid to flow freely through the valve in either direction. If maintenance is going to be performed on the flaps, the valve can be placed in the closed position. This will prevent fluid from reaching the flap selector valve.

You must remember, however, that after the maintenance is accomplished, the manually operated valves must be returned to their normal operating position for flight.

Exercises (407):

1. What are the three basic parts of an automatic check valve?

2. Why is the spring of a check valve relatively weak?
3. What causes the cone to go on seat of an automatic check valve?
4. Which check valve has a ball follower? What is it used for? Using the schematic in figure 2-4, determine in which position you should place the valves to operate or isolate specified systems.
5. In what position will the manually operated check valve be placed to operate the bomb door system only?
6. In what position will the manually operated check valve be placed to operate the flaps only?
7. In what positions are the manually operated check valves placed before flight?
8. What would be the result if check valve (H) were installed backwards, the aircraft engines were shut down, and the motor-operated pump were turned on?

408. Specify the correct operational features of the fluid flow path and installation procedures of a quick disconnect coupling.

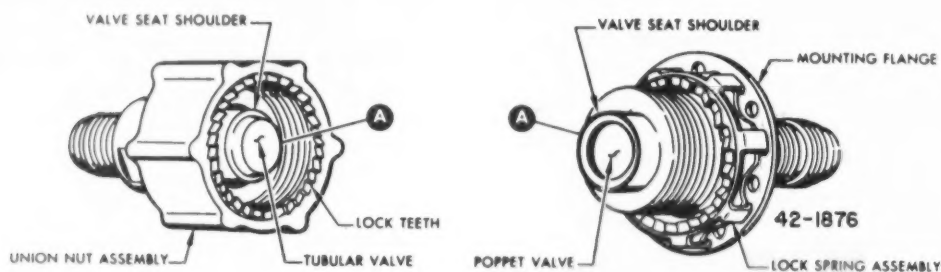


Figure 2-5. Quick disconnect construction.

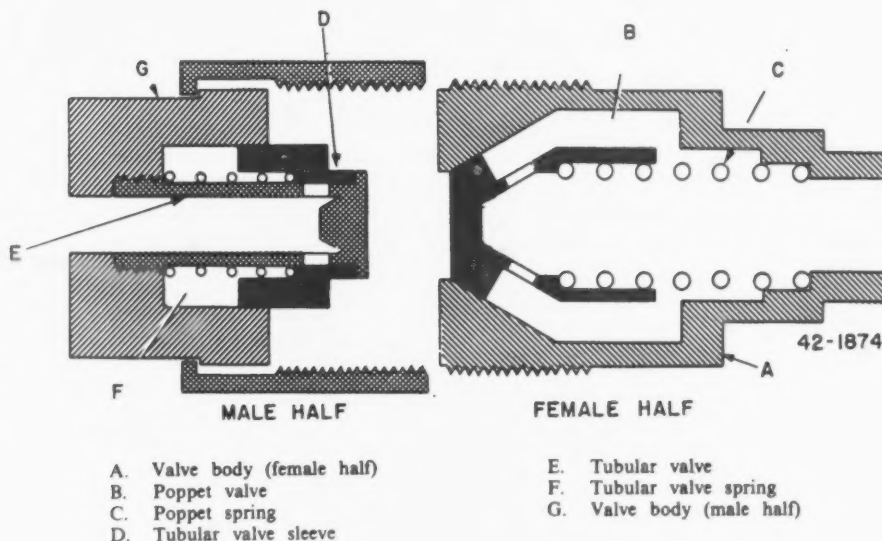


Figure 2-6. Quick disconnect (disconnected).

Quick-Disconnect Couplings. Quick-disconnect couplings of the self-sealing type (fig. 2-5) provide a means of quickly connecting or disconnecting a line without the loss of hydraulic fluid and without allowing air to enter the system. These couplings are installed at various locations in the hydraulic system where the frequent uncoupling of lines is required. An example for the location of the quick disconnects would be the suction or pressure line of an aircraft power pump. They can also be used to connect a portable hydraulic test stand to the aircraft in order to perform ground maintenance.

Figure 2-5 shows a quick disconnect commonly found in the aircraft hydraulic system. This valve consists of two interconnecting sections, which are called the female half (on the right) and the male half (on the left). The female half is made up of a poppet valve with a lock spring assembly. The male half consists of a tubular valve and a union nut assembly, which has lock teeth. The lock teeth lock in place with the lock spring to prevent the union nut from vibrating loose.

Figure 2-6 shows the two halves separated. In the female half, the poppet spring (C) is pushing the poppet valve (B) on seat against the valve body (A). In the male half, the tubular valve spring (F) is pushing the tubular valve sleeve (D) so that it covers the holes in the tubular valve (E).

Figure 2-7 shows what happens when the two halves are screwed together. When the valve is being connected, the union nut assembly screws on to the female half body (A), which draws the two halves together. The female half body (A) contacts the tubular valve sleeve (D) and compresses the tubular valve spring (F) until it bottoms out on the

male half body (G). This opens the holes in the tubular valve (E). If you continue to screw the two halves together, the tubular valve (E) will contact the poppet valve (B) and compress the poppet valve spring (C). This forces the poppet valve (B) away from the female body (A).

You can see (fig. 2-7) that, with the quick disconnect connected properly, fluid can flow through the holes in both the tubular and poppet valves and out to the system.

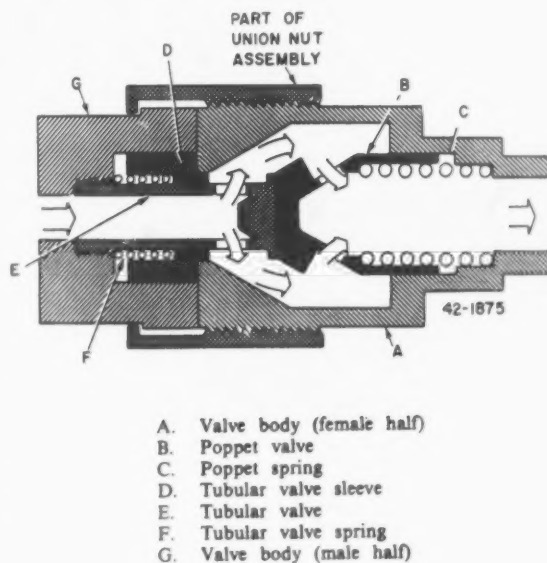
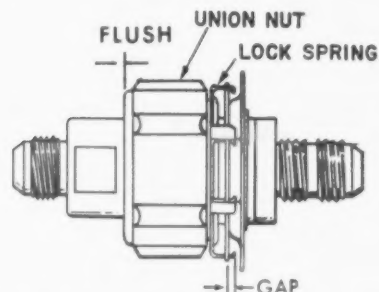
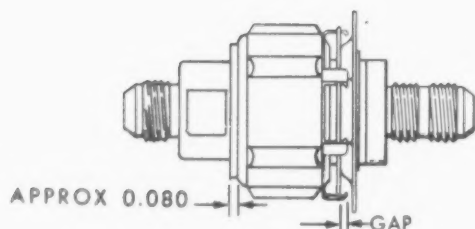


Figure 2-7. Quick disconnect (connected).

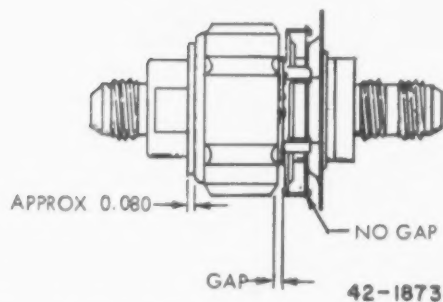
Disconnecting the quick disconnect is basically the reverse of the connection except for one feature. The union nut has left hand threads. When you turn the union nut to disconnect the fitting, it screws forward and compresses the lock spring even further, forcing it away from the ratchet teeth of the union nut sleeve. Now, as you continue to unscrew the union nut, it contacts the flange of the union nut sleeve and unscrews it from the female half body. The whole purpose of having left hand



A- COUPLING PROPERLY TIGHTENED



B- COUPLING TEETH DISENGAGED
(LOCKSPRING STILL COMPRESSED)



C- COUPLING UNSCREWED ONE FULL TURN

Figure 2-8. Proper connection of quick disconnect.

threads on the union nut is to release the lock spring from the ratchet teeth of the union nut sleeve.

A very important factor in the use of the line disconnect valve is its proper connection. For example, if the suction line to a pump is not connected properly, it could starve the pump of fluid; if the case drain line is improperly connected, it could cause the pump case to crack; and if the pump pressure line quick disconnect is not properly connected, you will not get the fluid you need to operate the hydraulic systems.

The lock spring is a safety feature which prevents the union nut sleeve from backing off due to aircraft vibrations. You can tell if the two halves are locked by listening for an audible clicking sound when the union nut sleeve's ratchet teeth contact the lockspring. Refer to figure 2-8,A, which shows you how you can tell if the quick disconnect is properly tightened. Notice that the back side of the union nut is flush with the union nut sleeve. Also notice that there isn't any gap between the union nut and the lockspring. Because the lockspring was compressed by the union nut sleeve, it caused a gap between the lockspring and the lock spring stop. This gap should be a minimum of 1/16 of an inch. The drawings in figure 2-8,B, and 2-8,C, show you two quick disconnects which are improperly connected together.

Bear in mind that this disconnect valve is only one of the many types presently used. Although all line disconnect valves operate on the same principle, the details will vary. Each manufacture has his own design features. If you are in doubt the line disconnects operation, consult the aircrafts technical order.

Exercises (408):

1. What are the two halves of the quick disconnect called?
2. What is the purpose of the quick disconnect?
3. Why is the lockspring considered a safety feature?
4. On this type of quick disconnect, how can you tell if the two halves are locked together?

5. What is the minimum gap allowed between the lock spring and lock spring stop when properly tightened?
6. What is the purpose of having left hand threads on the union nut?
7. When the two halves are properly connected, how does fluid flow through them?
8. How is the tubular valve spring in the male section compressed?
9. What forces the poppet valve off seat in the female section and uncovers the holes in the poppet valve?
10. What would happen if a quick disconnect were improperly installed in the suction line of a hydraulic pump?

409. Name the three basic categories of shutoff valves, and specify the constructional and operational features of each.

Shut-off Valves. The function of a shutoff valve will vary according to its installation on the airplane. All shut-off valves are used to control the flow of fluid. They can be opened to let fluid flow, and they can be closed to stop the flow of fluid. A

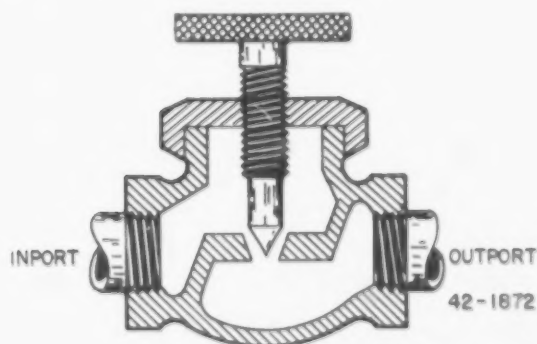


Figure 2-9. Manually operated shutoff valve.

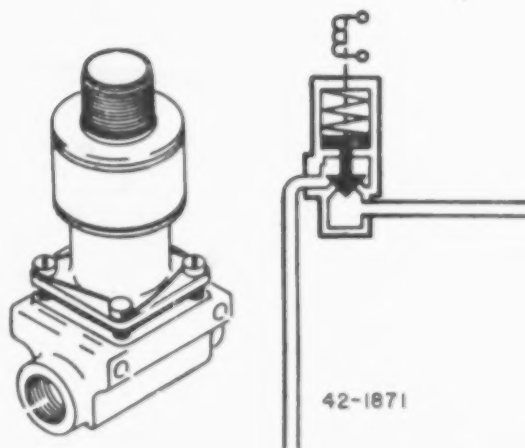


Figure 2-10. Solenoid operated shut-off valve.

manually operated shutoff valve can also be used to vary the amount of fluid flow by partial closing or opening of the valve. Though there are many types of shutoff valves, they basically fall into three broad categories: manually operated, motor-operated, and solenoid-operated. We will discuss each one individually.

Manually operated shut-off valve. The manually-operated shutoff valve shown in figure 2-9 is an adjustable flow control valve. Names that are commonly used for the manually operated shutoff valves are Globe and Needle. You can also think of the manually operated shutoff valve as a water faucet. The manually operated shutoff valve consists of a handle, stem, and body. Turning the handle in a clockwise direction places the valve stem on its seat within the body, thus stopping the flow of fluid. If a manually operated shutoff valve is used only during ground maintenance to shutoff fluid flow, it should be lock-wired in the open position during flight operation.

Solenoid-operated shutoff valve. Here again this valve can be used to shutoff the flow of fluid or be opened to let fluid flow. The valve's location in the system determines its purpose. Refer to figure 2-10. The valve has a body, solenoid, spring, and poppet. In this particular valve the spring is forcing the poppet on seat. When power is applied to this valve, the solenoid (coil of wire) creates a magnetic field that pulls the poppet off the body seat, thus allowing fluid flow from the inlet port to the outlet port. If the power were to drop off, the valve would be forced closed by the spring. In other solenoid-operated valves, the valve might be energized closed and spring-loaded open. Remember that it all depends on where in the system it is located and for what it is being used.

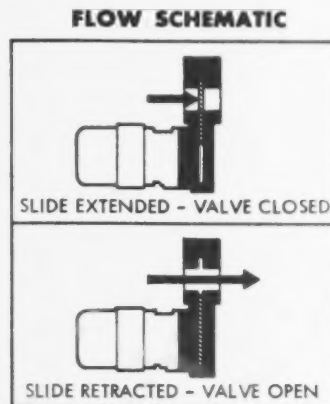
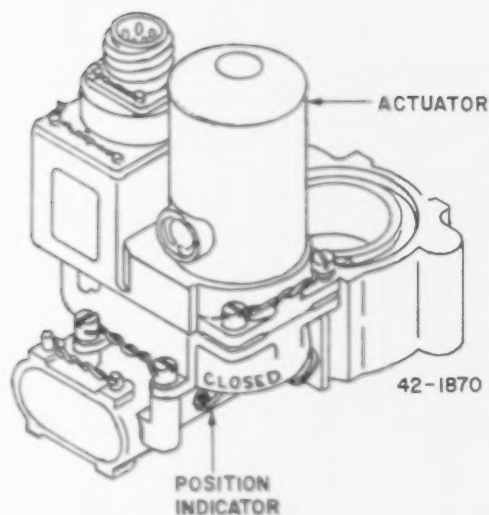


Figure 2-11. Motor operated shut-off valve.

Motor-operated shutoff valves. The motor operated shutoff valve (fig. 2-11) can be used to shut off the flow of fluid to the engine in the case of an engine fire. The motor-operated shutoff valve consists basically of an electrical motor, slide, valve body, limit switches, and indicator.

When the shutoff valve is energized, an electrical impulse is applied through an electrical connector to the motor. The motor converts the electrical energy into rotary motion. This rotary motion of the motor shaft is transmitted to the slide, which produces linear motion. This causes the slide to open or close.

When the valve is in the open position, the slide is retracted into the valve body, thus permitting the flow of hydraulic fluid through the valve. When the valve is in the closed position, the slide is positioned between the inlet and outlet ports, thus shutting off the fluid flow. The valve incorporates a visual position indicator (on the valve itself). The indicator is mechanically connected to the motor to provide a positive indication of the position of the valve. In case of electrical failure, the indicator can be manually operated to position the slide to open or close the valve. Limit switches in the motor will

shut off power to the motor when the slide moves to the fully closed or fully open position.

The electrical circuit for this valve will be similar to the one shown in figure 2-12. When the fluid shutoff switch is moved to the open position, it allows power from the 28V bus to flow through the limit switch to the motor, then to ground. The motor will move; and, as it completely opens, it will make contact with the open limit switch. This will break the electrical circuit, thus shutting off the motor.

Exercises (409):

1. For what else besides shutting off fluid flow can a manually operated shutoff valve be used?
2. What are the three basic categories of shutoff valves?

3. What are some common names for manual shutoff valves?
4. What determines the purpose of the solenoid-operated shutoff valve?
5. Which type of shutoff valve has an indicator to show if it's closed or open?
6. If the position indicator on the motor-operated shutoff valve is positioned to the closed position manually, what will happen if the shutoff switch is in the open position and power is applied?
7. What causes the motor-operated shutoff valve to shut off when it reaches the fully open or closed position?
8. What will happen if power is applied while a spring is forcing a solenoid valve on seat?

410. Indicate whether given statements correctly reflect the pressure regulator purpose and operation.

Pressure Regulator. Previously we discussed various types of power pumps. Although manufacturers are using more variable volume pumps, constant volume pumps are still being used. As an example, some aircraft in use today still use constant volume pumps with ram air turbines. These constant volume pumps run continuously; therefore, these aircraft need pressure regulators to maintain system pressure within the desired operating range. The regulator must be designed so that fluid can return to the reservoir when the system is fully pressurized. The bypass valve (see fig. 2-13) in the regulator does this job. A pressure regulator must also have a check valve that will trap the fluid under pressure in the system. This valve allows fluid flow into the system, but it prevents system fluid from flowing out through the bypass. A large spring is also included in the regulator to keep the bypass valve on seat.

Before we continue with this subject, we want to review the meanings of two terms. You must know them if you are to understand the operation of pressure regulator. These terms are "kick in" and "kick out." Basically, when we say that the pressure regulator is kicked in, we mean that the fluid from the pump is being directed through the check valve and into the system. When we say that the pressure regulator is kicked out, we mean that the fluid from the pump is being routed through the bypass valve, and out to return.

Figure 2-13 shows the pressure regulator kicked in. Note that the bypass valve is on seat and that the check valve is off seat. When a unit is operating and full pressure is required, fluid will enter from the pump, flow through the check valve, and exist the unit into the system. Pressure will build up until the required pressure is reached.

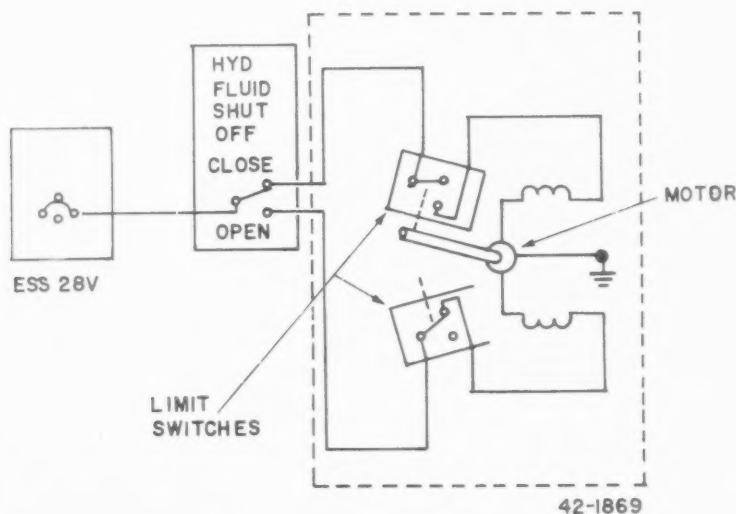


Figure 2-12. Motor operated shut-off valve electrical circuit.

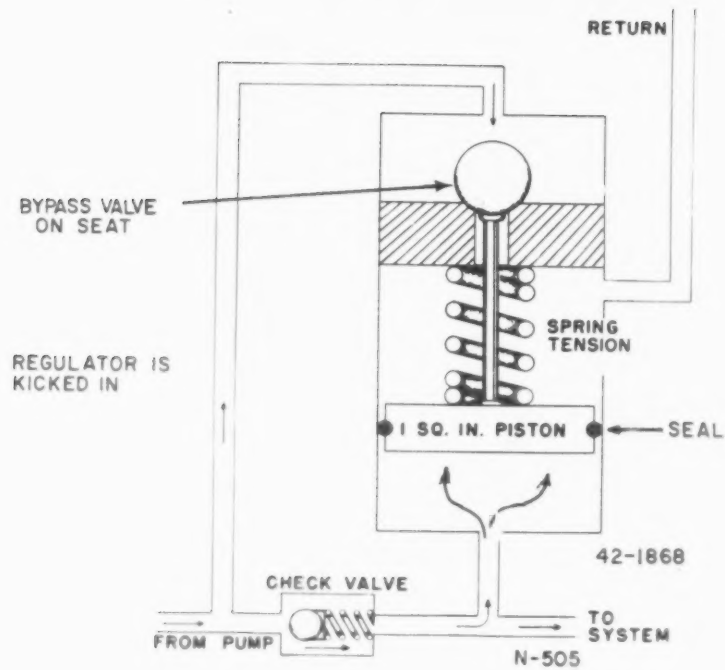


Figure 2-13. Pressure regulator (kicked in).

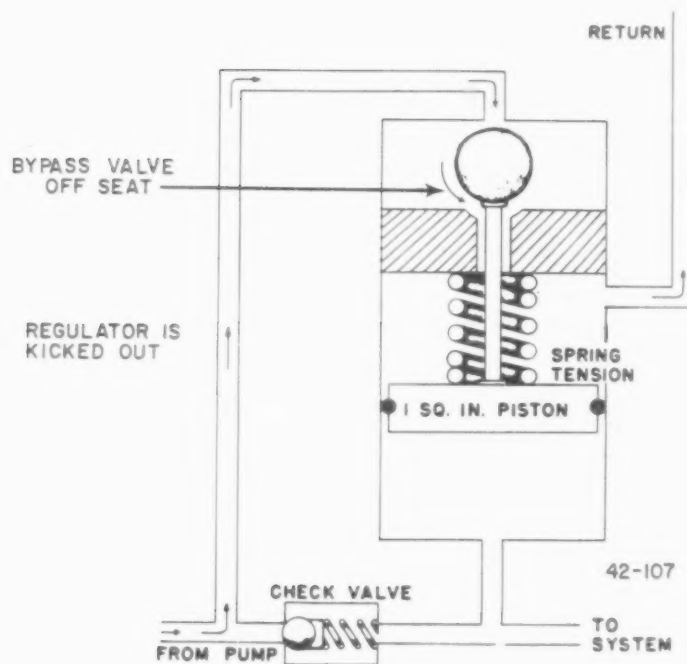


Figure 2-14. Pressure regulator (kicked out).

At that time the piston will be forced up enough to move the bypass valve off its seat. (See fig. 2-14.) Now the bypass opens, providing a return path for the pump output fluid. Since fluid will take the path of least resistance, it follows the return path back to the reservoir through the return line.

The high system pressure also combines with the spring tension in the check valve and forces the check valve on seat. With the check valve closed, the system remains pressurized. This condition of the regulator is known as kicked out. The pump will continue to operate.

We can expect trouble-free operation from the pump for a longer time because the pump is not constantly under a load. The pressure regulator will remain in this position until the pressure drops to a certain point. When this happens, the spring forces the bypass valve rod and piston down until the bypass valve is closed. With the bypass closed, the pump's fluid output can no longer go directly to the return. Fluid pressure will build up between the pump and the regulator. This pressure will open the check valve, and the fluid will reenter the hydraulic system, where it will build up the pressure to the desired amount.

The difference between the regulator kick in pressure and the regulator kick out pressure is known as the operating range.

The pressure regulator is a reliable piece of equipment and causes little trouble to the hydraulic system. The major problem you will have with a pressure regulator is internal leakage. This can cause the regulator to have an early kick-in or a late kick-out. A leaking check valve will cause the valve to kick in sooner. A leaking bypass valve will cause the regulator to have a late kick-out.

Exercises (410):

Indicate whether the following statements are true or false by placing a T or F in the blank provided. Correct the false statements.

1. When the regulator is in the kicked in position,

- a. The flow is directed through the check valve and into the system.
- b. The flow is directed past the bypass valve and into the return.
- c. Spring tension forces the bypass valve on seat.

- d. Pressure under the piston forces the bypass valve off seat.

2. When the regulator is in the kicked out position,

- a. The flow of fluid is directed into the pressure manifold.
- b. Fluid passes through the regulator and into the return line.
- c. The check valve ball is off seat.
- d. The spring's force is greater than the force produced by the pressure in the system.

3. Pressure regulators maintain the hydraulic system pressure within a desired range. _____

4. The difference between the regulator kick in pressure and the regulator kick-out pressure is known as differential pressure. _____

411. Specify the relief valve that would be best suited for a particular installation, and calculate the settings of relief valves for given situations.

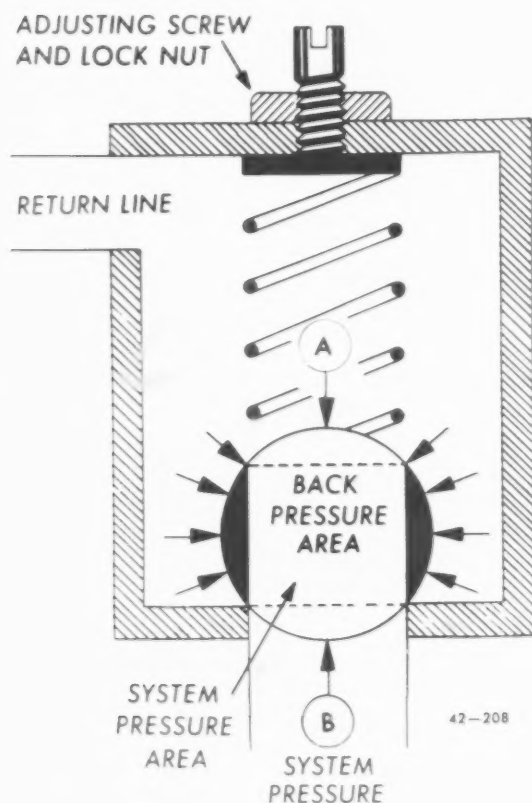
Relief Valves. Relief valves are simply pressure-limiting devices. They prevent pressure from building up to a value that would burst the fluid container or tubing. How could this happen when we have a pressure regulator or pump compensator to control pressure? It couldn't normally, but, if one of these units should fail, the relief valve is there as a backup safety device.

Main system relief valve. This relief valve is normally installed between the pressure and return lines. It will limit the maximum pressure reached by dumping the excess pressure into the return line. Thus, the main system relief valve must be large enough to pass the pump's full output back to the return. If a pump puts out 9 gpm of fluid, then the relief valve must be large enough to allow the full 9 gpm to pass through it and back to return. If the

relief valve were not big enough to allow this, then the pressure would continue to build up and eventually rupture the line.

Thermal relief valves. These valves are of the same construction as the main system relief valves, but they are smaller in size. The reason they are smaller is that they are designed to relieve only small quantities (one or two drops) of fluid due to thermal expansion. These valves are located in isolated parts of the system where a check valve or selector valve keeps excessive pressure from being relieved through the main system relief valve. These thermal expansion relief valves are commonly labeled "TERVs." The operation of the main system and thermal expansion relief valves are basically the same.

Figure 2-15 shows a typical relief valve. The pressure from the system enters the pressure port and pushes upward on the ball. If this pressure is high enough to overcome the compression spring, the ball will be pushed off its seat. Now fluid from the system can go out the return line. The adjusting screw merely increases or decreases the force of the



- A. Area upon which back pressure exerts a downward force
- B. Area upon which system pressure acts

Figure 2-15. Relief valve.

spring. As a result, it requires more or less pressure to unseat the ball. The lock nut is used to lock the adjusting screw in place.

In this relief valve the system's pressure acts against a large spring. The spring doesn't need to be as strong as you may think, because the pressure acts on only a small area. Let's say the valve needs to relieve at 2000 psi. If the ball seat area of the relief valve is 1/4 square inch, the spring force need be only 500 pounds. The formula $F = A \times P$ can be used to find the spring force. For example, Force = 1/4 sq. in. (Area) X 2000 psi (pressure) = 500 lbs.

Thus far we have considered only the spring force that must be overcome before the valve relieves. In the hydraulic system, however, we also have some pressure in the return line. Return line pressure is caused by resistance in the return line (such is the case when the reservoir is pressurized). This back pressure, which may be as high as 250 psi, helps to hold the ball on its seat. The area on which this back pressure works effectively can be seen in figure 2-15. The back pressure acts all the way around the ball, except on that portion exposed to the system pressure. The back pressure acting on one side of the ball is canceled by the pressure that is acting on the other side. This means that system pressure (B) must overcome the back pressure that acts only on the top of the ball (A). The pressure at which the valve will relieve increases directly with an increase in back pressure.

If this relief valve is to operate properly, the system pressure must overcome both the spring tension and back pressure. For example, if the valve has a 150 psi back pressure, and a spring tension set to relieve system pressure at 2000 psi, it would take 2000 + 150 psi, or 2150 psi, to unseat the ball.

Balanced outlet relief valve. Some relief valves are constructed so that back pressure cannot affect the operation of the valve. Notice the way the housing is constructed in figure 2-16. It is so constructed that the back pressure in the return line (D) cannot act against the back side of the seat (C). This will allow the valve to open at a preset amount without having to worry about back pressure. The thing to remember is that this valve does not eliminate back pressure, but it does eliminate the effective area that the back pressure can act upon. Without an area that pressure can act against, there will be no force. This relief valve consists of a cylindrical housing stamped to identify the ports as PRESS (pressure) and RET (return). Let's see now how this valve operates. The large spring (E) forces the seat (C) against a stop on the valve housing, and the small spring (F) forces the poppet valve (B) against the seat assembly. This is known as the closed position. When fluid pressure at the pressure port (A) reaches a preset amount, the pressure forces the seat (C) to compress the large spring. As the seat moves, it unseats from the

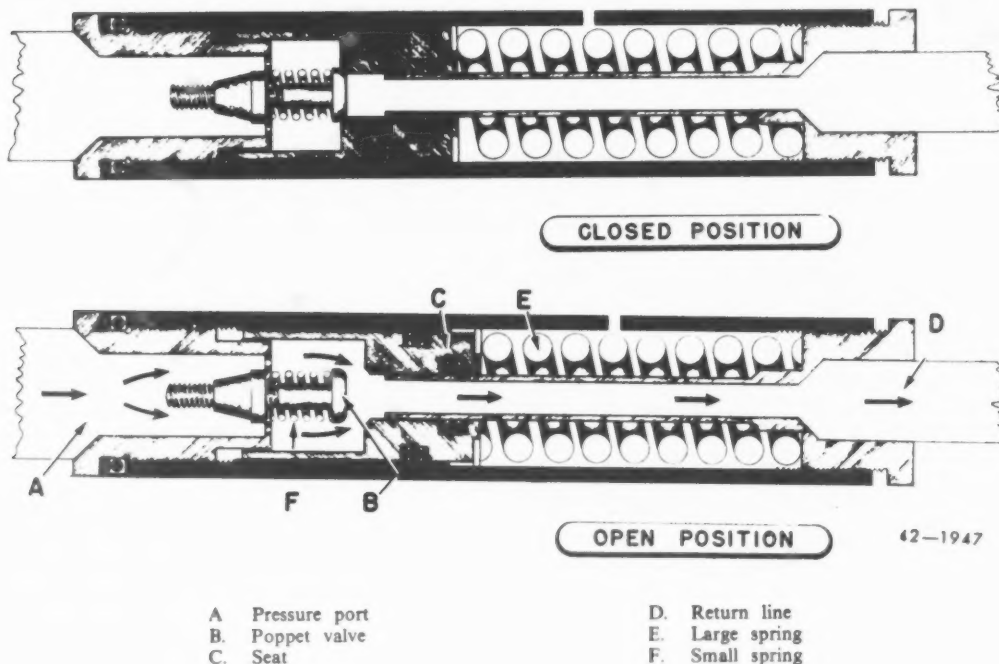


Figure 2-16. Balanced outlet relief valve.

poppet valve (B), and fluid flows through the valve into the return line (D). Here again notice that the back pressure in the return line cannot get behind the seat assembly to affect the pressure setting of the relief valve. This creates a balanced condition of the pressure entering the valve and the spring tension on the piston. No amount of back pressure can prevent this valve from opening at its set amount.

Maintenance of Relief Valves. Relief valves, normally require little maintenance. However, they do occasionally fail. The most common trouble you will find with relief valves is internal leakage. This can be caused by damage to the poppet or seat. If the valve is leaking badly, it will become very hot and also will make a hissing noise.

The repair that your shop will perform on relief valves depends on the type of valve and the available facilities. Some types of relief valves cannot be repaired. Others may be disassembled, inspected, repaired, and reassembled. These procedures will vary, depending on the design of the particular valve. Relief valves usually have an adjustment for increasing or decreasing the pressure at which they relieve.

Most relief valves are adjusted to the cracking pressure. This is the pressure at which the ball or poppet is slightly unseated. At this pressure, only a few drops of fluid are relieved. It is approximately 15% above the normal system pressure. If more fluid needs to be relieved, the ball will rise higher and allow full output to be relieved. This is called

the valve's full flow pressure. It is about 10 percent higher than cracking pressure because the spring must be compressed further. After the valve has relieved fluid and the pressure drops, the ball must stop fluid flow around it. Fluid tends to continue flowing once it has started. Therefore, the spring cannot force the ball onto its seat until pressure has dropped about 10 percent below cracking pressure. The pressure at which the return flow is cut off is called the reseating pressure.

An example of the pressure involved when adjusting a relief valve is shown below.

Normal system pressure	—	3000 psi
Cracking pressure	—	3450 psi
Full flow pressure	—	3795 psi
Reseating pressure	—	3105 psi

Exercises (411):

1. If one system is to be isolated from the other, what type of relief valve would be used?
2. What type of relief valve would normally be used if a preset relief setting were critically needed?

3. Refer to figure 2-15 to help you determine the following answer. Situation: A relief valve had a spring tension of 1000 pounds, an area on which the inlet pressure can act upon the ball of $1/2$ of an inch, and no back pressure. At what pressure would the relief valve open?
4. Situation: The normal system pressure is 2500 psi. What are the cracking, full flow, and reseal pressures?

2-2. Accumulators, Filters, Coolers, and Manifolds

What is the purpose of the radiator on a car? What are the purposes of intake and exhaust manifolds on a car? Why must the oil filter on a car be changed periodically? I'm sure that you can answer these questions easily.

Can you as easily answer questions pertaining to the use, operation, and maintenance of hydraulic systems coolers, filters, accumulators, and manifolds? As a pneumatic systems mechanic, you will encounter these units as you perform your job.

This section has been designed to provide you with the answers to the above questions. In it we shall cover the use, construction, operation, and maintenance of accumulators, filters, coolers, and manifolds.

412. Name the two general types of accumulators, and match the type of cylindrical accumulator to the constructional feature associated with it.

Accumulators. The purpose of the accumulator in a hydraulic system is to store a volume of fluid under pressure, provide space for thermal expansion, and act as a cushion against pressure surges in the hydraulic system. Accumulators are rated by capacity (50 cu. in.) and by system operating pressure (3000 psi). There are two general types of accumulators: the spherical and the cylindrical types. Until a few years ago, the spherical type was the more commonly used accumulator; however, the cylindrical type has proved more satisfactory for high-pressure hydraulic systems, and has now become the more commonly used accumulator.

Spherical accumulator. The spherical accumulator (fig. 2-17) is constructed like a globe or ball. Mounted inside the sphere, a rubber diaphragm or bladder (C) is used to separate the fluid chamber (B) from the air chamber (D). A screen (A) located in the pressure port prevents a part of the diaphragm from being pushed out through the port and being damaged. In some units a metal disc is attached to the center of the

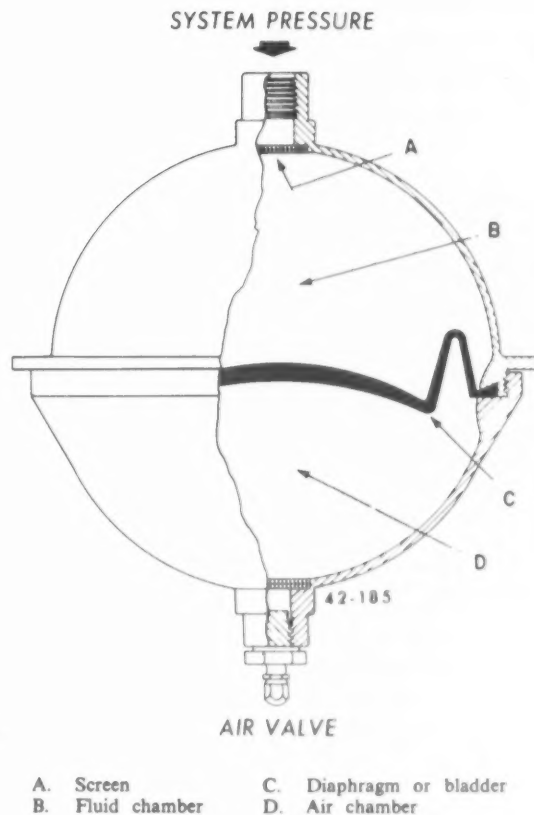


Figure 2-17. Spherical accumulator.

diaphragm and is used in place of the screen. This type of accumulator is usually mounted in the aircraft with the air chamber at the bottom. A schrader (air servicing) valve is used to service the air side of the accumulator with dry air or nitrogen.

Cylindrical accumulator. There are many cylindrical types of accumulators, each one slightly different than the next. We will try to explain the construction of the most common ones used.

a. Spring-loaded. This type of accumulator is better known as a compensator—something which equalizes or balances two or more opposing things. In figure 2-18 you can see that the compensator construction consists of a housing (A), a piston with seal (B), a large spring (D), and an end cap (E). In some compensators an indicating rod attached to the piston protrudes through the end cap. This would be used to indicate the amount of fluid inside the compensator.

When the compensator is empty, the large spring (D) forces the piston (B) up. As fluid enters the inlet port (C), it overcomes the spring force and pushes the piston down. The fluid will be stored in the compensator until it is needed in the system. Whenever the system pressure drops off, the spring will force the piston up and force the fluid out of

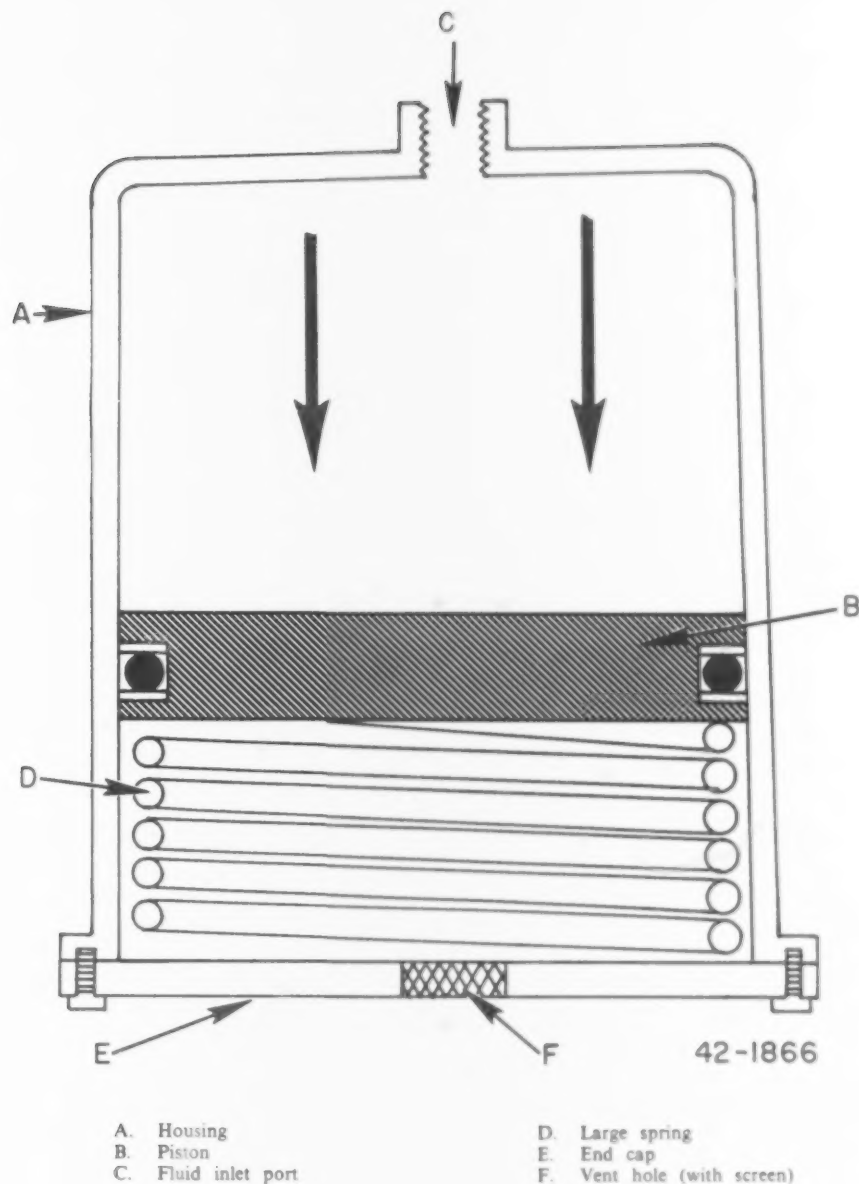


Figure 2-18. Compensator.

the compensator and into the system. A vent hole (F) in the end cap (E) allows atmospheric air to enter and exit as the piston moves up and down. You will see later on in this volume that the compensator can be used alone or be incorporated into other units.

b. Piston. The piston accumulator uses dry air or nitrogen to act like the spring in the compensator. In figure 2-19 you can see the piston type of accumulator. It basically is constructed of a cylinder barrel (B), two end caps (A), and a piston

(C). The end caps have seals to prevent external leakage. The piston is built with a hollow end; this end will always be toward the air side of the accumulator. Also the piston will have a seal to prevent internal leakage between the fluid side and the air side. This particular accumulator piston has two seals. With two seals, it will prevent the piston from cocking and binding as it moves up and down. There is a drilled passage (D) in the piston so that fluid from the fluid end of the accumulator can enter and lubricate the bottom piston seal. An



air servicing valve (E) is located at the bottom of the accumulator for servicing the unit with dry air or nitrogen.

connected together by a rod. The piston (B) is the only moving part of the accumulator. It slides up and down through the inside of the accumulator housing.

1. Match the type of accumulator from column B to the constructional features in column A associated to it. Some of the items in column A may require two answers:

Column A	Column B
<i>Constructional Features</i>	<i>Type of Accumulator</i>
— (1) Uses air pressure instead of spring tension.	a. Compensator.
— (2) Has spring tension instead of air pressure.	b. Piston.
— (3) Has a vent hole.	c. Self-displacement.
— (4) May have an indicating rod to show how much fluid it has stored.	d. Spherical.
— (5) Has a drilled passageway in the piston for lubrication.	
— (6) Has four separate chambers.	



477

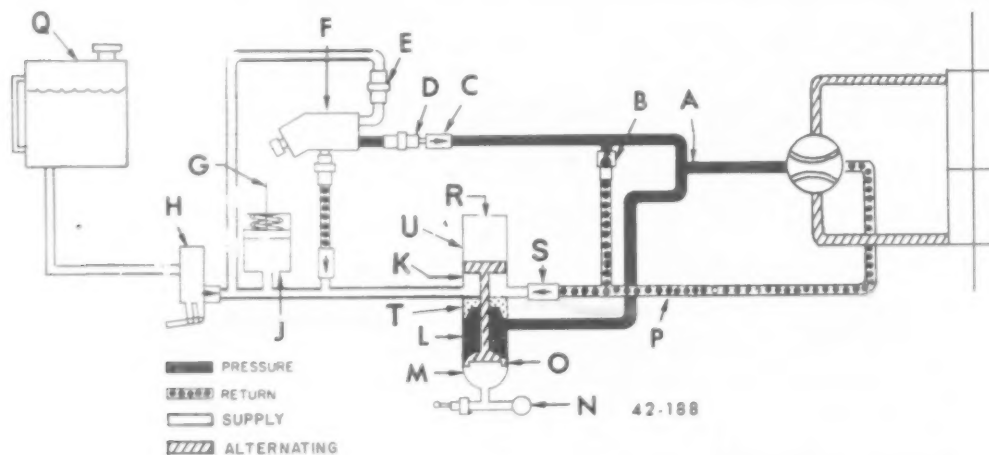
3. An accumulator in the shape of a tube is called

Self-Displacing Accumulator System. The self-displacing accumulator acts as a conventional accumulator to store a volume of fluid under pressure, and also acts as a system reservoir under normal conditions. This allows the aircraft to be at any altitude or flight attitude (including vertical or inverted) and still maintain a constant fluid supply to the pump. Figure 2-21 shows a complete hydraulic system with a self-displacing accumulator. Now follow along as we talk about the system's construction and operation.

First let's set the system at zero pressure. Without any hydraulic system pressure, the air

charge in the self-displacing accumulator air chamber (M) forces the piston (O) to the top of the accumulator, forcing atmospheric air pressure to be vented out the vent port (R). The compensator (J) spring forces the piston of the compensator down until it bottoms on the compensator inlet port. The indicating rod (G) indicates the amount of fluid stored in the compensator.

With the system set up like this, the engine-driven pump (F) would cavitate because of the lack of fluid supply to the pump. So, to insure a positive fluid supply to the pump, you have to pressurize the supply system. In order to do this, you will have to use the hand pump (H). By pumping the hand pump, you will draw fluid from the main system reservoir (Q) and pump it into the supply system of the self-displacing accumulator system. Notice that the fluid from the hand pump can go all the way through the quick disconnect valve (E) to the pump. It also fills the supply lines up to the return line check valve (S). The fluid also fills the storage space (K) of the self-displacing accumulator because the piston (O) is all the way at the top. As you continue to pump the hand pump, it will build up pressure in the supply system. As pressure builds up, it forces the piston of the compensator to compress the spring. We now have a closed system with every portion of the supply system from the return line check valve (S) to the pump pressurized



- A. Actuating subsystem
- B. Relief valve
- C. Check valve
- D. Quick disconnect (pressure)
- E. Quick disconnect (supply)
- F. Pump
- G. Compensator indicating rod
- H. Hand pump
- J. Compensator
- K. Storage space

- L. Pressure chamber
- M. Air chamber
- N. Air pressure gage
- O. Accumulator piston
- P. Return line from subsystem
- Q. Main system reservoir
- R. Vent hole
- S. Return line check valve
- T. Fixed piston
- U. Vent chamber

Figure 2-21. Self-displacing accumulator system.

by the spring of the compensator. Now let's see what happens when the aircraft engine is started.

As the pump (F) starts to operate, the compensator spring force the fluid from the compensator into the supply port of the pump. This insures a positive fluid supply during the initial starting of the engine-driven pump. As the pump rotates, it produces a fluid flow. Notice that it can go out to the actuating subsystem (A), and it can also enter the pressure chamber (L) of the self-displacing accumulator. As the pressure builds up in the chamber (L), it overcomes the initial air charge and forces the piston (O) to move down. Because the piston (O) is forced down, it causes the fluid in the storage chamber (K) to be forced to the engine pump supply port. As you can see, the self-displacing accumulator is now acting as a pressurized reservoir, and it also can act as a normal system accumulator.

Since the same amount of fluid is forced to the pump supply port as is forced by the pump into the pressure chamber (L), the system remains in balance at all times.

We will only mention just a few other components in the system. The check valve (C) is used to prevent fluid stored in the accumulator from entering the pump when the pump is not operating. The relief valve (B) is used to relieve excessive system pressure. Notice that it is between the pressure line and the return line.

Exercises (413):

Figure 2-21 can be used to answer these questions.

1. What is the purpose of the compensator?
2. What is the purpose of the relief valve installed in the system?
3. What is the check valve (C) used for?
4. What happens to the piston (O) when the pump builds up system pressure?
5. Which chamber of the self-displacing accumulator is serviced with fluid when the supply system is serviced with the hand pump?

6. After the pump is operating, how does the self-displacing accumulator pressurize the supply system?
7. The fluid flow produced by the pump goes to two places. What are they?
8. In the self-displacing accumulator, what must the fluid pressure that enters the pressure chamber (L) overcome in order to move the piston down?

414. List the three basic parts of a filter assembly, and specify constructional and operational features of a filter assembly.

Filter Assembly. Keeping fluid clean is very important in keeping the hydraulic system operating properly. No matter how well you may think you have maintained the system, you never really know for sure whether or not it is contaminated. One way of keeping the fluid clean is to place filters in strategic locations in the aircraft hydraulic system. This will provide an adequate control of the contamination problems you may encounter during normal system operation.

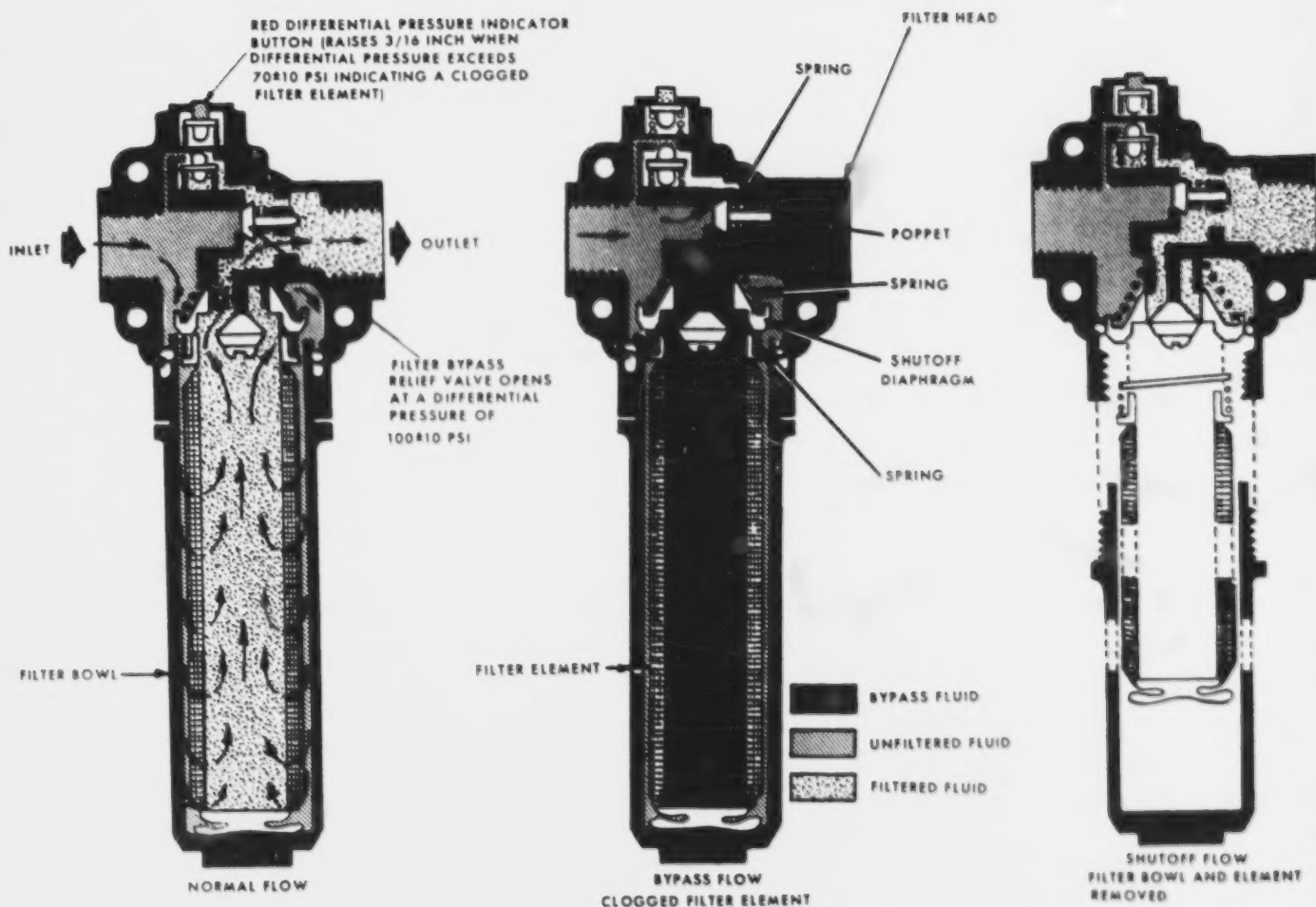
A typical hydraulic filter assembly is generally constructed like the one shown in figure 2-22. This particular filter assembly consists of three basic parts—head, element, and bowl.

Filter head. The filter head is normally mounted to the aircraft structure by mount bolts. It can be very simple or quite complicated, depending on the type of system or aircraft design. Some of the filter heads sub-components are listed below:

a. Bypass relief valve. This valve routes fluid from the inlet port to the outlet port if the filter element becomes clogged. As you can see figure 2-22, the bypass will open at 100 ± 10 psi.

b. Differential pressure indicator. It indicates when a filter element is creating a difference between the fluid entering the element and the pressure leaving it. The indicator is actually two spring-loaded magnets. When inlet pressure is higher than outlet pressure, the inlet pressure separates the two magnets, and a spring then forces the red indicator up. Here again, figure 2-22 shows that this particular filter button pops up at 70 ± 10 psi differential.

c. Shutoff diaphragm. This is used to prevent entry of air into the system and loss of fluid during maintenance (element replacement). The diaphragm shuts off when the filter bowl and element are



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Figure 2-22. Filter assembly.

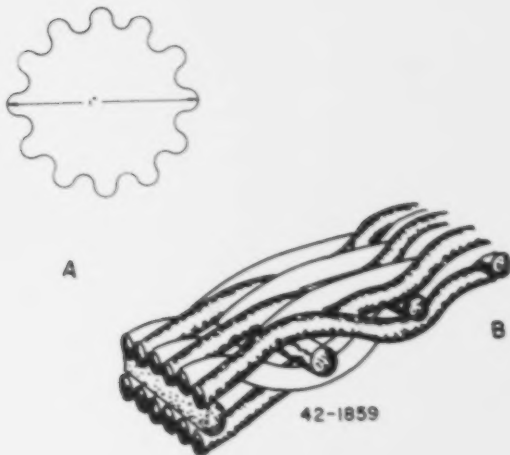


Figure 2-23. Filter element construction.

removed. It reopens when the filter bowl and element are reinstalled in the filter head.

Filter element. The second part of the filter assembly is the filter element. It is sometimes referred to as a micron element. Filter elements are constructed from many types of materials, but

the types most commonly used on aircraft are cellulose paper and woven wire mesh. Construction of the woven wire element can be seen in figure 2-23, B. Usually these are corrugated (made like an accordion), as shown in figure 2-23, A. This allows for strength and larger filtering area of the filter element. Filter elements are rated according to the amount of dirt or contaminants they can filter; this we call the micron rating. The size of one micron is 4 millionths of an inch, and the symbol for microns is μ . To visualize how small this is, just think of a grain of salt which is 70 microns in size. The smallest particle you can see is 40 microns. In today's hydraulic system, we often have filters that remove contaminants as small as 3 microns. So you can see that, even though a hydraulic system doesn't look dirty, it could still be contaminated with particles smaller than you can see with the naked eye.

A filter element can be absolute or nominal. If a filter is rated at 10 microns absolute, it will not allow any particles larger than 10 microns to pass through it. If a filter is rated at 10 microns nominal, it will filter out most of the particles 10 microns or larger, but some particles 10 microns or larger could possibly get through.

Filter bowl. The filter bowl is simple a bowl that fits over the filter element and screws into the filter

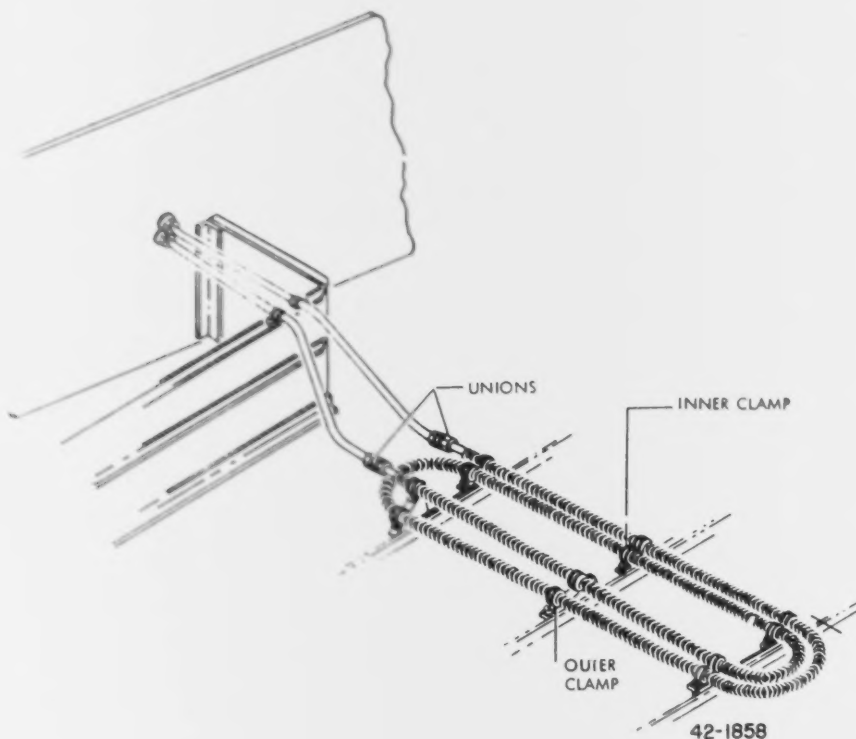


Figure 2-24. Cooling coil with fins.

head. The outside of some filter bowls are serrated, and others have a place on which you can place a wrench for removal and installation. Filter bowls more than likely will have a safety wire hole so that you can safety-wire it in place to prevent it from backing off.

Operation. Now that you understand the basic construction of a typical filter assembly, let's trace the fluid flow through it. In most cases the filter assembly will have two ways for the fluid to flow. One is the normal fluid flow, and the other is the bypass fluid flow. Refer again to figure 2-22 as we describe the fluid flow through a filter assembly.

a. Normal fluid flow. Fluid enters the inlet port of the filter assembly and goes down between the filter bowl and filter element. It then goes through the filter element and exists through the outlet port. Any contamination will be held or trapped on the outside of the filter element.

b. Bypass fluid flow. Fluid enter the inlet port; but, because the filter element is clogged, fluid pressure builds up enough to off-seat the bypass valve. This allows the fluid to go directly to the outlet port. When this happens, the contaminated fluid is sent directly into the system, which is better than having no fluid at all. To indicate when this has happened, a red differential filter button will pop out. This is caused by the inlet pressure of the filter forcing the spring-loaded magnetic piston downward, breaking the magnetic attachment between the indicator button and the magnetic piston.

Exercises (414):

1. What are the three basic parts of a filter assembly?
2. Which part of the filter assembly is normally mounted to the aircraft?
3. What is meant by micron rating?
4. What does it mean when a filter element is rated at 15 microns absolute?
5. What are the two ways fluid can flow through a filter assembly?
6. What will cause the red indicator button to pop out?

7. What prevents fluid loss during maintenance?

415. Specify constructional and operational features of fluid coolers; and, given selected situations, use figure 2-25 to determine what valves would be open and closed.

Hydraulic Fluid Coolers. These items are used in the hydraulic systems for the purpose of lowering the temperature of the fluid within the system. Fluid coolers are normally located in the return lines to cool the fluid as it flows back to the reservoir. Several types of fluid coolers are used on aircraft. One of the simplest types of fluid coolers consists of thin walled tubing with fins. (See fig. 2-24). The heat is transferred from the fluid through the tubing to the fins. Air flow (or, in some cases, fuel) is used to pick up the heat from the fins. Notice in figure 2-24 that the finned tubing is routed through a fuel cell. The heat of the hydraulic fluid is absorbed by the fuel in the cell, heating the fuel to make it more volatile. This allows the fuel to burn more efficiently. Sometimes this tubing is placed inside a housing, as shown in figure 2-25. With this type of system, the hydraulic fluid is cooled by dissipating the heat into the air for fuel or both. Follow along as we trace the flow of fluid through this type of cooler.

The three thermal actuators shown in figure 2-25 will expand when heated and contract when cooled, and, as they do, will actuate various valves in the cooler. There is an oil inlet port and an oil outlet port, with a fluid cooler bypass valve, which will be open when the temperature is low or the inlet pressure is high. Notice that the air passes through a ram air valve (butterfly valve), past the thermal actuators, and around the cooling coils, then exits out the bottom. The fuel enters through the fuel inlet port and flows through several pencil-size passages, around the cooling coils, and exits out the bottom. Notice that a fuel bypass valve is installed to bypass the fuel in case the fuel passages become clogged. A fluid-cooler bypass valve is installed to bypass the fuel cooler when the temperature of the air in the air cooler is low. A temperature switch located at the bottom of the fluid cooler causes a caution light in the cockpit to come on if fluid temperature rises too high.

Now that we know the various components in the fluid cooler, let's describe its operation. Normally, when the fluid temperature is low, the thermal actuator attached to the fluid cooler bypass valve will pull the fluid cooler bypass valve off seat. This will allow the fluid to flow directly from the inlet port to the outlet port. As the fluid temperature rises, the thermal actuator will expand and force the fluid cooler bypass valve on seat. This will cause the fluid to flow through the air cooling

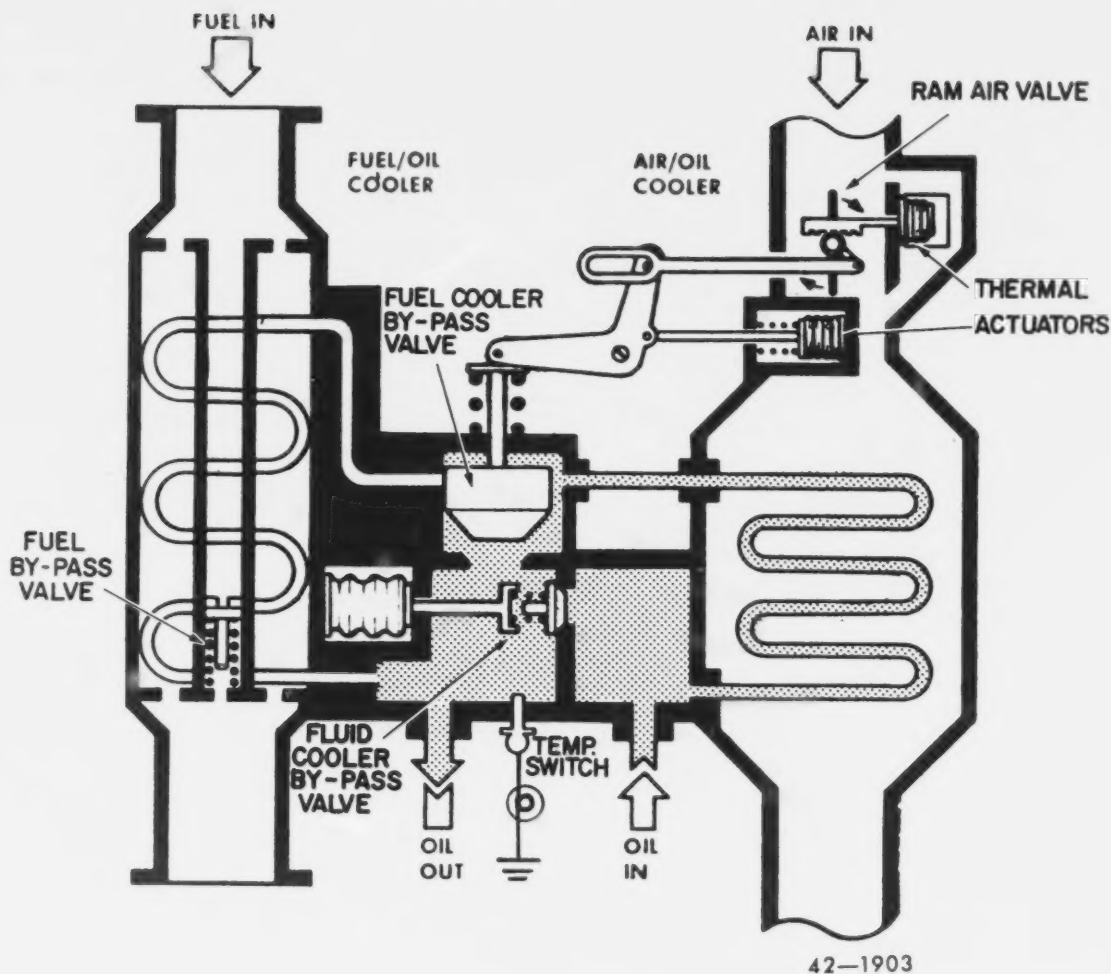


Figure 2-25. Fluid cooler.

coils, past the fuel cooler bypass valve, and out the fluid outlet port. When ram air temperature entering the air cooler reaches a certain temperature, the thermal actuator will push the fuel-cooler bypass valve on seat. This will cause the hydraulic fluid to flow through both the air cooler and the fuel cooler. If the ram air temperature continues to rise due to the high speed of the aircraft, the thermal actuator connected to the ram air inlet valve will expand and close the ram air inlet valve. This shuts off the air flow over the air cooling coils. The cooling of the fluid will now be taken care of by only the fuel cooling coils.

Exercises (415):

1. What would cause the caution light in the cockpit to come on?
2. If the air cooling coils were to get clogged, what would probably happen?
3. What would cause the ram air inlet valve to close?
4. Why is routing the hot hydraulic fluid through the fuel system advantageous?
5. Using figure 2-25 and the situations below, determine which valves are open and which are closed.

- a. Fluid flowing through both the air cooler and fuel cooler.
- b. Fluid flowing only through the air cooler.
- c. Fluid flowing through neither the air cooler nor the fuel cooler.

416. State the purpose of fluid manifolds, and specify the constructional and operational features of a typical manifold.

Manifolds. Manifolds are used in many hydraulic systems to provide a location where common fluid lines can come together. Their design is such that they conserve space in the aircraft and permit ease of unit removal and replacement. Figure 2-26 illustrates a hydraulic system manifold. This type of manifold has several filters through which fluid under pressure is directed to the various hydraulic

subsystems before it returns to the reservoir.

This particular manifold incorporates a relief valve, three check valves, two quick disconnects, and three filters with bypass and differential pressure indicators. System pressure enters port A, flows through filter A, and exits through ports E and G. High pressure in the system is relieved by the integral relief valve. Return fluid enters through ports B and C, flows through a filter, and is then directed to port H for a common return to the reservoir. Port D is provided with a quick disconnect for external application of hydraulic pressure. Port F also has a quick disconnect for external servicing of the reservoir. Both of these quick disconnects have dust caps. In either case, the fluid entering and leaving the manifold is passed through a filter to remove any contamination from the system. The manifold is designed so that any valve, filter, or quick disconnect can be removed without disturbing any other part of the assembly. Figure 2-27 shows a selector valve type of manifold assembly. The manifold can be designed to accommodate any number of selector valves, and it is supplied with pressure and return ports common to all the attached valves. Notice that this manifold has four valves that can be electrically actuated or manually operated by pushing the manual override

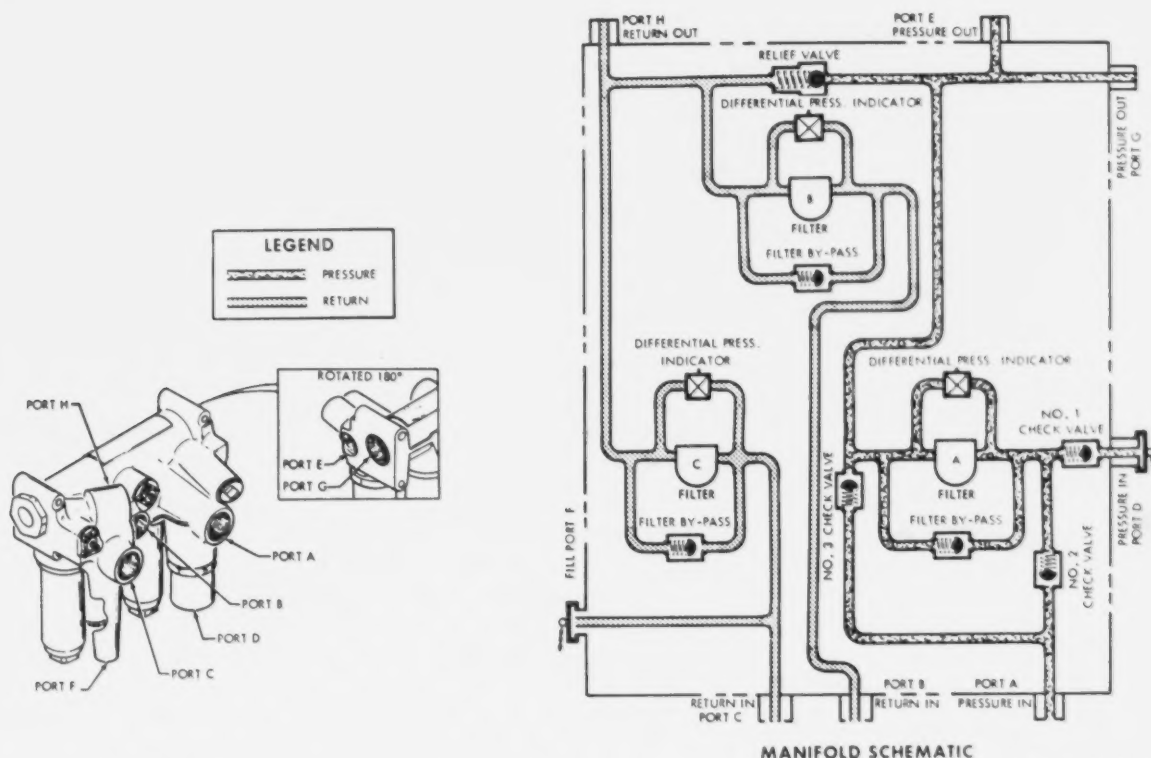


Figure 2-26. Manifold with Internal components.

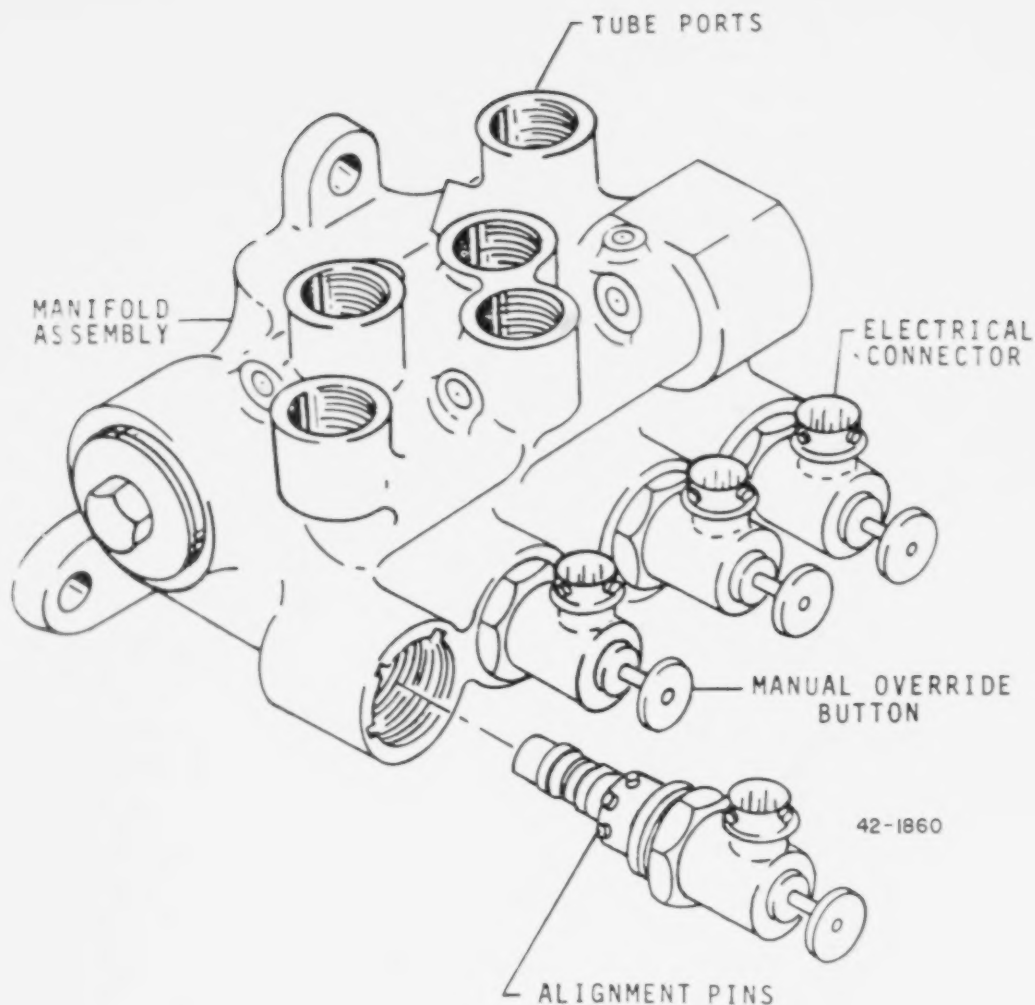


Figure 2-27. Selector valve manifold.

buttons. Each valve comes complete with seals and is installed without any further assembly or disassembly of the unit. To prevent the wrong valve from being installed in a manifold, alignment pins are used to make it physically impossible to install the wrong valve. In order to remove one of these valves, you don't have to disconnect any lines or mount bolts; you simply unscrew the valve from the manifold.

Exercises (416):

1. What are the two basic reasons for having fluid manifolds?

Using figure 2-26, answer the following questions:

2. When the reservoir is serviced with fluid, which filter will the fluid have to flow through?
3. What prevents the pressure from leaving port D if the quick disconnect cap is removed?
4. What component relieves excessive internal pressure?

2-3. Pneumatic Components

Now that we have talked about the units typical of those most often found in the hydraulic power

system, let's talk about the units in the pneumatic system. In many instances, the units found in the pneumatic system are similar to the ones found in the hydraulic system. A check valve found in the hydraulic system can very easily be used in the pneumatic system, or vice versa. But, in other instances, the pneumatic units are quite different, and for this reason we have separated this section from the typical hydraulic components. In this section we will discuss air compressors, moisture separators, air flakes, chemical driers, and air servicing valves.

417. Specify the purpose, construction, and operational features of an air compressor.

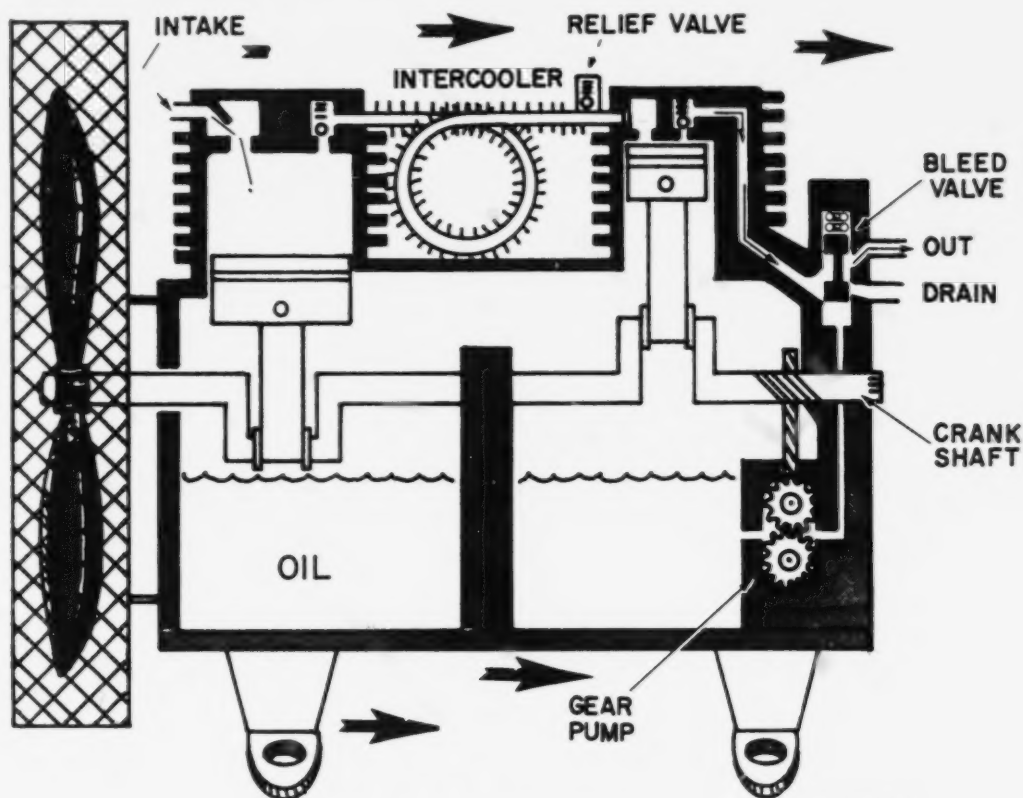
Air Compressor. Speaking in a broad sense, an air compressor is nothing more than a pump that produces an air flow. A bicycle pump is an air compressor, but in a much simpler form.

Compressors are identified according to their volume (cubic feet per minute) output. They are also identified according to their pressure output.

As an example, an air compressor would be rated at 2.5 cfm at 3000 psi.

Construction. See figure 2-28. For simplicity, only two cylinders are shown. The air compressor is a combination of several other units that we have already discussed previously, so we will not go into very much detail on these items. The compressor contains its own cooling and lubrication. The cooling system consists of a caged fan that circulates cooling air over the unit to provide adequate heat dissipation. The intercoolers are constructed of finned tubing. Also notice that the cylinder heads have fins. To lubricate the rotating components within the compressor, a gear pump is provided. The pressure relief system consists of a pressure relief valve and a bleed valve. The relief valve protects the compressor between the various stages against a pressure buildup. The bleed valve will direct the air flow from the compressor, depending on the pressure output of the oil pump.

Operation. As the crank shaft is rotated, air is drawn through the intake valve into the first stage cylinder by the suction created on the downward (intake) stroke of the piston.



42-1886

Figure 2-28. Air compressor.

On the upward or compression stroke, this intake valve is forced shut by the increasing pressure, and the spring-loaded discharge valve is forced open. The compressed air is directed through the discharge valve and into the intercooler connected to the first stage head. As the compressed air passes through the intercooler, the heat created during compression is dissipated through forced convection by the air flow from the fan directed over the intercoolers. The flow of cooled compressed air passes by the first stage relief valve and into the second stage cylinder during the downward (intake) stroke of the second stage piston. On the compression stroke of the second stage piston, the air is forced out the discharge valve, through the bleed valve, to the high pressure air outlet.

This compressor is lubricated with oil which is taken from the oil reservoir. The gear pump is driven through a connection with the crankshaft. A drilled passage in the crankshaft directs the oil pressure produced by the gear pump to the moving parts of the crankshaft and pistons. The oil which collects in the compressor crankcase splash-lubricates the cylinder walls. Oil is also applied to the piston of the bleed valve and holds the valve piston in the closed position. When the oil pressure drops off (due either to restriction of oil flow or to the stopping of the compressor), the spring within the bleed valve repositions the bleed valve piston, connecting the in port to the drain port of the valve. This action unloads the pressure from the compressor and purges the line of moisture.

Exercises (417):

1. What is the purpose of the air compressor?
2. What is the purpose of the fan on the compressor?
3. What is an intercooler?
4. What is used to lubricate the moving parts of the compressor?
5. What is the purpose of the bleed valve?
6. What draws the air into the first stage of the compressor?

7. When will the bleed valve be open to unload the compressor?

418. Specify the constructional and operational features of a typical moisture separator.

Moisture Separator. The moisture separator is the pneumatic power system's pressure sensor-regulator and relief valve. The separator assembly is made up of several sub-components, each of which performs a specific function. The components are shown on figure 2-29 and described in the following paragraphs.

Pressure switch. The pressure switch controls system pressure by sensing the system pressure between the check valve and the relief valve.

Condensation dump valve. The condensation dump valve solenoid is energized and deenergized by the pressure switch. When energized, it prevents the separator from dumping air overboard; and, when deenergized, it completely purges the separator reservoir.

Filter. The filter protects the dump valve port from becoming clogged and thus insures proper sealing of the passage between the reservoir and the dump port.

Relief valve. The relief valve protects the system against overpressurization (thermal expansion). Notice that it relieves pressure in the outlet line but not from the reservoir itself because the check valve is on seat.

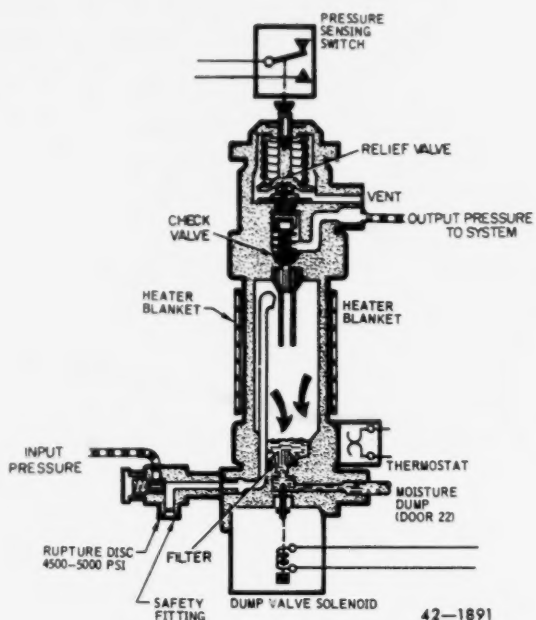


Figure 2-29. Moisture separator (blown down condition).

Check valve. The check valve protects the system against pressure loss during the dumping cycle and prevents backflow through the separator to the air compressor during the relief condition.

Thermostat and heating element. The thermostatically controlled wrap-around blanket heating element prevents freezing of the moisture within the reservoir. The thermostat closes to complete an electrical circuit to the heating blanket when the atmospheric temperature reaches 40° F.

Safety fitting. The safety fitting assembly installed in the inlet port of the moisture separator is composed of a flame arrestor screen, rupture disc, and housing. The flame arrestor, a cylindrical shaped fine mesh steel screen, prevents the passage of hot carbon particles that come from the air compressor. A steel metal disc is designed to burst or rupture when excessive pressure builds up inside the moisture separator.

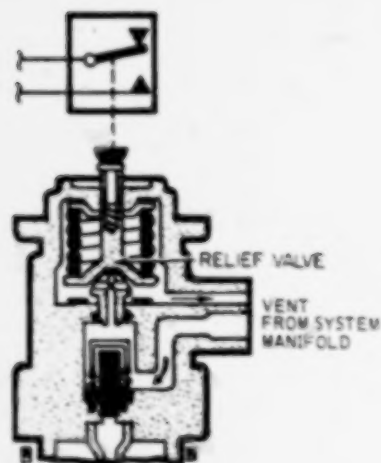


Figure 2-31. Moisture separator (relief condition).

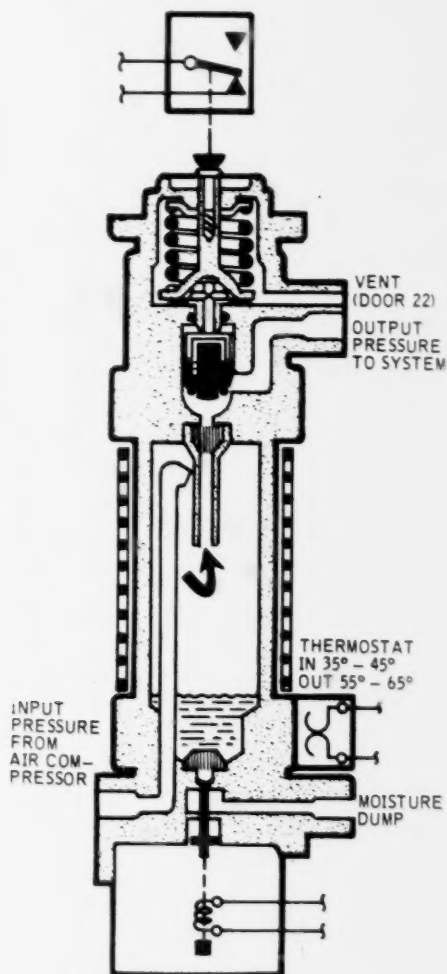


Figure 2-30. Moisture separator (charged condition).

Operation of the Moisture Separator. This unit has three operating positions—charged condition (fig. 2-30), blown down condition (fig. 2-29), and relief condition (fig. 2-31). Pressure from the air compressor enters the safety fitting and flows into the center of the moisture separator. (See fig. 2-30). The moisture falls to the bottom, and the air pressure flows through a tube with a filter, off seats the check valve, and goes out to the subsystem. As pressure builds, it pushes up on the pressure switch and breaks the electrical circuit to the dump valve. (See fig. 2-29). The dump valve is spring-loaded OPEN so that, when the electrical power is dropped off, the valve opens and purges the separator of moisture. As long as the pressure in the subsystem is maintained, the moisture separator will remain in this position. If thermal expansion builds up in the subsystem, it will force the relief valve open (fig. 2-31) and vent itself to the atmosphere.

Exercises (418):

1. What pressure does the relief valve relieve when it is open?
2. What component energizes and deenergizes the dump valve solenoid?
3. What takes place when the dump valve is deenergized?

4. What is the purpose of the check valve?
5. What could happen if the thermal blanket did not work when the temperature dropped below freezing?
6. What are the parts of the safety fitting?

419. Specify the constructional features and the moisture-removing features of the air flasks and chemical driers; specify how and why a desiccant cartridge is replaced.

Pneumatic Storage Bottle (Air Flask). The air storage flask (fig. 2-32) is made of fiber glass or steel. It may be either cylindrical or spherical in shape. The container serves as a trap for moisture as well as an air storage space. The manifold assembly (view A-A, fig. 2-32) is made up of the in and out ports, plus a moisture drain fitting. Cooling of the high pressure air in the storage cylinders will cause some condensation to collect. To insure positive operation of the system, the storage cylinder must be purged of moisture

periodically. This is done by slightly cracking the moisture drain fitting located on the cylinder manifold. Some air bottles are wrapped in a strong wire, which helps cut down on flying shrapnel in case the air bottle should rupture. When the bottle is in use, high pressure air from the pneumatic system enters the "in" port through the inlet tube and goes into the storage chamber. As air is needed in a subsystem, the air in the storage chamber goes up through the outlet tube to that subsystem. Any moisture caused by condensation falls to the bottom of the storage chamber. Because the outlet tube is higher than the moisture level, only dry air will enter the subsystem. The drain fitting and tube are used to purge the moisture from the air bottle periodically.

Chemical Drier. Chemical airdriers are installed in air systems to absorb moisture that may collect from the air entering the system. The main parts of the airdrier (fig. 2-33) are the housing, desiccant cartridge, filter (porous bronze), and spring.

In the cartridge is a desiccant, or drying agent. Another name for the chemical drier is dehydrator. To insure proper filtering, the air must pass through the air drier in the proper direction. The correct direction of flow is indicated by an arrow and the word "flow" printed on the side of the cartridge.

Preventive maintenance of this component consists of replacing the cartridge when it becomes saturated. To replace the cartridge shown in figure

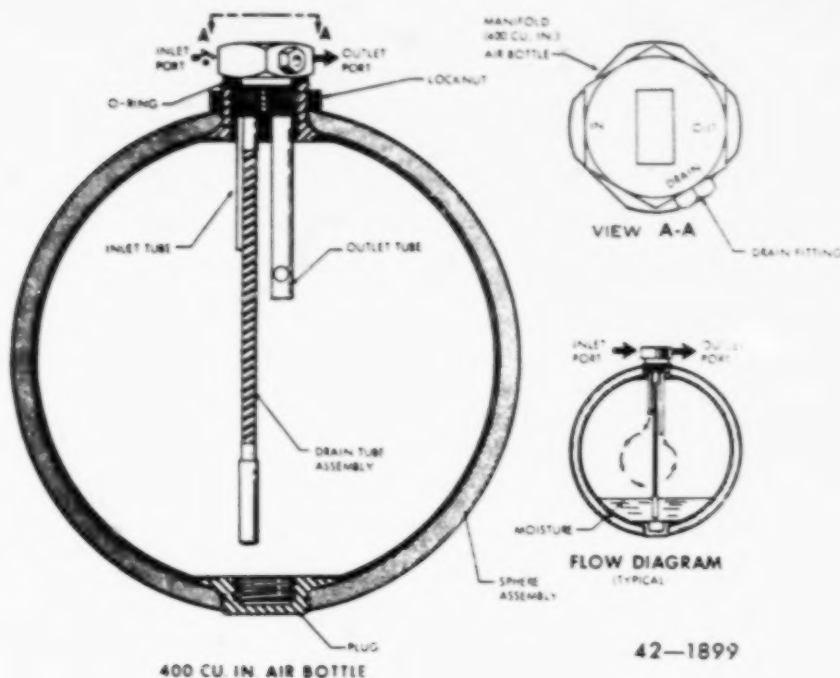


Figure 2-32. Air storage flask.

2-33, the following procedures should be used.

Bleed the air from the system. Remove the plug from the outlet end of the airdrier housing and discard the O-ring seal. Next remove the old cartridge and spring from the housing, and discard the cartridge. Remove the protective covers from the new cartridge. (If the protective covers are not removed, the air will not flow through the cartridge.) Place the spring over the inlet end of the cartridge, and insert both the spring and the inlet end of the cartridge into the air-drier housing. (Remember to install the cartridge so that the arrow is pointing in the direction of the outlet port.) Then reinstall the outlet end plug, using a new O-ring seal. Finally, pressurize the system and check for leaks.

Exercises (419):

1. What, besides an air storage bottle, is the air flask used for?
2. Why are air flasks wrapped in strong wire?
3. How is condensation removed from the air flask?
4. Define the word "desiccant."

5. How is moisture from the chemical drier removed from the system?
6. When a new desiccant cartridge is placed in the air drier housing, in what direction should the arrow on the cartridge be pointed?

420. Specify the purpose and operation of the air servicing valve.

Air Servicing Valve. The high-pressure air servicing valve (PN MS-28889) shown in figure 2-34 is used on struts, accumulators, and various other components that must be serviced either with high-pressure air or with nitrogen. An air chuck similar to the one shown in the insert of figure 2-34 is needed during servicing of these units.

The air servicing valve consists of three parts: the body nut (hex section), the valve stem, and the swivel nut. The body nut has external threads which allow the nut to be screwed into the item that needs to be serviced. It does not form an airtight seal; therefore, an O-ring seal must be used to prevent leakage. It also has holes drilled in it so it can be safety-wired. The valve stem has external threads which mate with the threads of the swivel nut. The valve cap prevents dirt and moisture from entering the valve. The pin which is between the valve stem and the body nut prevents the valve stem from screwing all the way out of the body nut. Notice that there is an O-ring seal between the valve stem and the body nut. This prevents leakage between the valve stem and body nut during servicing. On the bottom of the valve stem is the

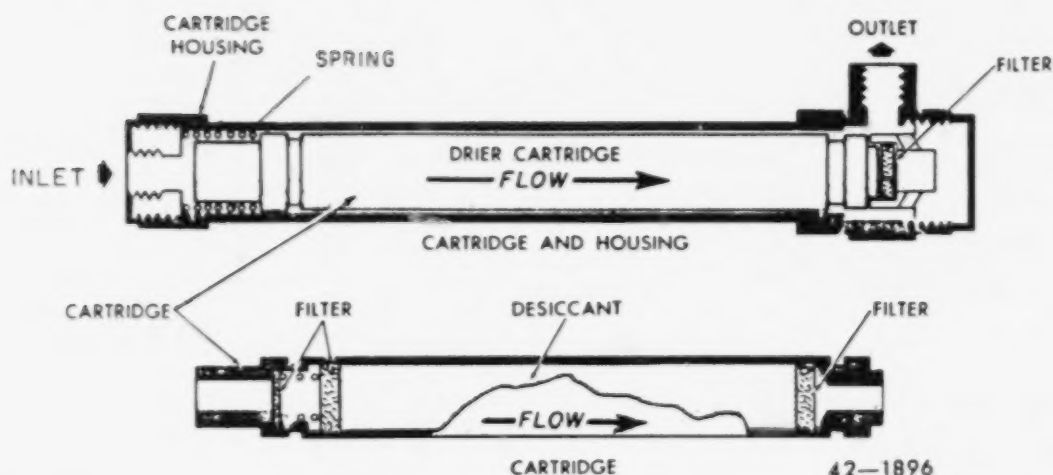


Figure 2-33. Chemical drier (dehydrator).

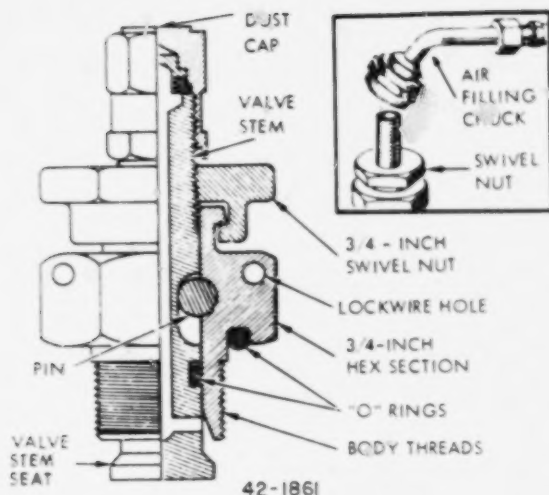


Figure 2-34. Schrader valve.

valve stem seat. It forms a positive metal-to-metal seal with the body nut.

Suppose that you want to service a component while it is operating. First, remove the valve cap. (There are certain safety precautions that you should understand before you continue: One is that you should never loosen the body nut (lower nut) when the system or unit is pressurized. This can cause the whole valve assembly to be blown off, which could easily result in serious injury to personnel and equipment. Another precaution is that you should hold the body nut with another wrench when loosening the swivel nut.) With the valve cap removed, open the valve by slowly turning the swivel nut counterclockwise about 3/4 of a turn. This causes the valve stem to move down and break the positive metal-to-metal seal. Air can now flow through the center of the valve stem and either enter or exit depending on whether you are servicing or releasing the air.

In order to close the air servicing valve, you will have to turn the swivel nut clockwise. This causes the flange of the valve stem to go on seat with the

body nut. Recommended torque of the swivel nut is 50 to 70 inch pounds. After the swivel nut has been properly torqued, install the valve cap fingertight. Another type of air servicing valve (part number AN 6287) is also used. It may be found occasionally on older type aircraft. It is similar in construction to the MS 28889 servicing valve except for two distinct areas. First the swivel nut is 5/8 of an inch rather than 3/4 of an inch. Secondly, this valve has a core, similar to the valve core you have in your car tire. If you do run across this type of valve, be sure to depress the valve core to release the air pressure after the swivel nut is loosened.

Exercises (420):

1. What prevents the valve stem from screwing all the way out of body nut?
2. Name the three basic parts of the air servicing valve.
3. What prevents leakage of the valve when it is tightened down?
4. Why should you never loosen the body nut when the system or unit is pressurized?
5. Distinguish the difference between an AN and MS air servicing valve.
6. What is the purpose of the air servicing valve?

Indicating System Components

IN THIS CHAPTER we will discuss the most commonly used pressure and position-sensing devices found on aircraft today. Without some type of sensing system, the pilot will not know if his hydraulic system is functioning properly or that his flaps or landing gear are at the proper position. Can you imagine a pilot flying around thinking his hydraulic system has 3000 psi when in reality the pressure dropped off the minute he took off? Can you imagine a pilot's not knowing that one of his gear is up and locked and that the other is down? This chapter is broken down into two sections. One section will deal with direct reading pressure gages, and the other section will talk about the indirect reading systems that use electrical transmitters and indicators.

3-1. Direct-Reading Indicators

Most pressure-sensing devices are forms of metal containers that will expand, contract, or straighten out when pressure is applied to them. In this case we have selected a hydraulic pressure gage that uses a bourdon tube to show this application. Direct-reading pressure gages fall into two categories. They are absolute pressure or differential pressure-measuring gages. An absolute pressure-measuring device shows the pressure above atmospheric pressure. The differential pressure-measuring device shows the pressure above or below atmospheric pressure.

421. Indicate whether given statements correctly reflect the principles of operation of a bourdon tube.

Bourdon Tube. The bourdon tube is the basic mechanism of the high pressure indicating instruments used on today's aircraft. It was designed over a hundred years ago by Eugene Bourdon. He applied some internal pressure to a coil of flattened copper tubing to restore its shape. He found that, as the tubing was made round again by the pressure, it also uncoiled. When the pressure was released, it would coil again. The bourdon tube shown in figure 3-1 is made of metal tubing, oval or somewhat flattened in cross section. The metal

tubing is closed at one end and mounted rigidly in the instrument case at its other end. The fluid pressure to be measured is introduced into the fixed end of the bourdon tube by a small tube leading from the fluid system to the instrument. The greater the pressure of the fluid, the more the bourdon tube tends to straighten. Since the fluid pressure will be transmitted equally in all directions and since the area on the outside radius of the tube is greater than that of its inside, the force will also be greater on the outside radius. This then will cause the tube to straighten. When the pressure is reduced, the coiling action of the metal tube causes it to curve back to its original shape.

Exercises (421):

Indicate whether the following statements correctly reflect the principles of operation of the bourdon

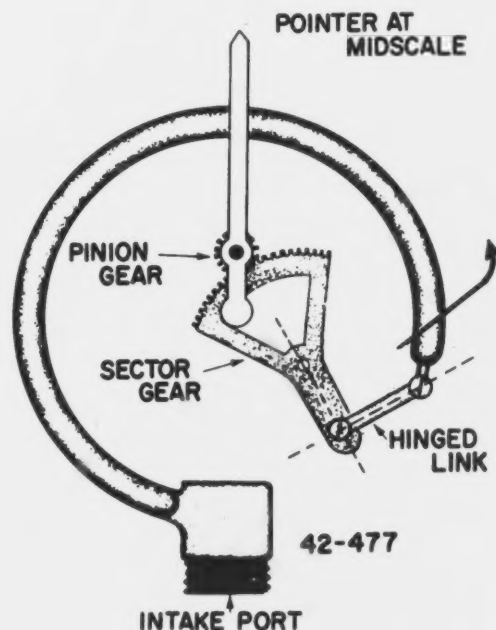


Figure 3-1. Bourdon tube.

tube by placing a T or F in the blank space. Correct the false statements.

- 1. The bourdon tube is open at both ends.
- 2. When pressure is applied to the bourdon tube, the outside radius area of the tube will have a greater force; thus, the tube will straighten out.
- 3. The coiling action of the metal tube causes it to return to its original shape when pressure is removed.

422. Specify the operational features of a direct reading pressure gage, and specify the common problems and troubleshooting procedures encountered.

Direct-Reading Pressure Gage. The hydraulic pressure gage is used to measure the pressure in the hydraulic systems. It has a bourdon tube device enclosed in a case. The range of this gage depends on the wall thickness and stiffness of the bourdon tube. Refer to the bourdon tube shown in figure 3-1. Notice that one end of it is rigidly fastened to the intake port and that the other end is attached to the hinged link. When pressure is applied to the tube, the outward movement of the tube pulls the hinged link in the direction of the arrow. This motion is transmitted to the sector gear, which rotates the pinion gear and the attached pointer. The pointer will then indicate the amount of pressure applied.

Most direct reading gage problems fall into two categories: fluctuating (oscillating) pointers, and high and low readings. However, these gages have a high longevity and seldom cause trouble.

The simplest way to begin troubleshooting is to substitute a good pressure gage for a suspected bad one. If the trouble still exists, it stands to reason that the fault is in the system and not in the gage. If the substitute gage shows a normal reading, then the trouble has been isolated to the suspected gage.

An oscillating pointer of a pressure gage is usually caused by air trapped in the line going to the gage. This oscillation can be corrected, in most cases, by removing the air. The bleeding operation is done by first placing an open container under the pressure line going to the gage. This is to catch any liquid that drains out during bleeding. With pressure on the system, slowly loosen the

connection at the rear of the gage until a small amount of liquid comes out. As the trapped air comes out of the line, you will see a bubbling effect. Allow the connection to remain loose until the bubbling stops and the liquid flow is steady. Retorque the connection and perform an operational check of the system. Some direct reading gages have a bleeder connection on the rear of the indicator. In this case, it is not necessary to loosen the pressure connection.

Exercises (422):

1. What are the two categories of problems of direct reading gages?
2. Describe the simplest method for troubleshooting a direct reading pressure gage.
3. What procedure will usually remedy an oscillating pointer on a direct reading pressure gage?
4. To what unit is the motion of the hinged link transferred?
5. What will determine the range of the gage?

423. Given a list of phrases, match each with the appropriate pressure reading or range mark.

Pressure Readings. There are many different pressure gages that can be used in the hydraulic or pneumatic systems. The gages are calibrated to match the systems they accommodate. Notice in figure 3-2 that the gage is marked psi $\times 1000$. This means that the 1 represents 1000 psi, the 2 represents 2000 psi, etc. If you have to replace a direct reading gage, make sure that you replace it with one that has the same pressure readings.

Range Markings. Range or limit markings on gages show the pilot at a glance that flight operations are safe, desirable, or unsafe. Range markings are decals applied to the glass over the scale ranges given in the aircraft technical order. The index mark (slippage mark) is a white radial line painted on the instrument glass and extended onto the gage case. It is placed at an uncalibrated portion of, or at the bottom of, the gage dial. This mark will show if the cover glass has shifted. The

shift of the cover glass causes the range and limit markings to be in error. A slippage mark is applied to all instruments that have range or limit markings on the cover glass. Listed below are the other range markings you will find on gages.

The red radial line marker shows maximum or minimum operating range.

The red arc marker shows prohibited operating range.

The green arc marker shows normal operating range.

The yellow arc marker shows undesirable operating range.

Exercise (423):

- Match the phrases listed in column A with the correct response pressure reading or range marking listed in column B by writing the letter in the blank provided. Since there is only one response for each condition, some items in column B will not be used.

Column A

- (1) Indicates 300.
- (2) Indications of safe, desirable, or unsafe flight operations.
- (3) Indication of glass shifting.
- (4) Color indicating normal operating range.
- (5) Indicates maximum or minimum operating range.
- (6) Indicates 3,000 psi.

Column B

- a. Red arc marking.
- b. Range markings.
- c. Green arc markings.
- d. 3×1000 psi.
- e. Slippage mark.
- f. 3×100 psi.
- g. Red radial line marking.
- h. Yellow arc marking.

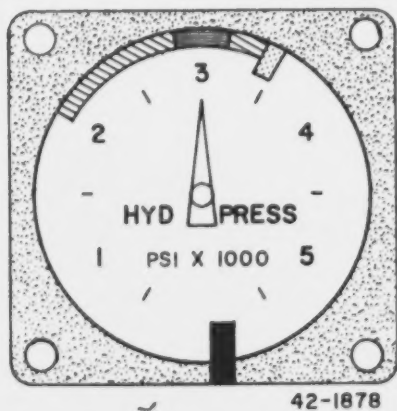


Figure 3-2. Pressure gage markings.

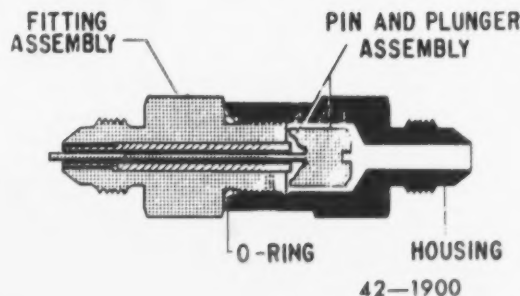


Figure 3-3. Snubber valve.

424. Specify the purpose and operation of the snubber.

Snubber. On many pressure gages, the pressure port has a built-in orifice which restricts the flow of fluid entering and leaving the gage. This prevents the normal surging action of the pump, plus the rapid building up and dropping of pressure in the system, from damaging the gage. It also prevents violent oscillation of the pointer. If this orifice is not built into the gage, then you should have a snubber (see fig. 3-3) in the pressure line to the pressure gage or transmitter. The snubber serves as an orifice (small opening) in the line, preventing pressure surges from getting to the gage at full force. The basic components of the snubber valve is the housing, which has a fixed diameter orifice, and dampening plunger (pin). The energy of system pressure surge is absorbed in the form of a pressure drop as the surge flows through the fitting assembly orifice. The pin is pushed and pulled through the orifice of the fitting assembly by the plunger. This keeps the opening clean and at a uniform size, assuring against any changes in the snubbing action over a long period of time. The plunger is free to move back and forth; but, because of its inertia, it tends to remain stationary. The weight of the plunger thus opposes the pressure surges in the fluid and cancels out most of them before they reach the pressure gage. The reduction of the surges results in a steadier pointer indication and therefore a more accurate reading. When installing snubbers, be sure that the end marked "GAGE" is installed towards the pressure gage or transmitter.

Exercises (424):

- What is the purpose of a snubber?
- Where is the snubber shown in figure 3-3 installed?

3. If the pressure gage does not have the snubber shown in figure 3-3, what will be used to restrict the flow of fluid entering and leaving the gage?
4. What is the purpose of the pin found in the snubber shown in figure 3-3?

3-2. Indirect-Reading Indicators

You have learned that direct reading pressure gages require tubing between the point where the pressure is measured and the point where the indicator is mounted in the cockpit. Because modern aircraft have become larger, the requirements for more monitoring instrument systems have also become greater. The transmission of various liquid pressures through a system of tubing would increase the weight of the aircraft. It would also mean that flammable liquids were present in the cockpit, an undesirable condition for safety reasons. These factors brought about the design of the synchronous instrument systems. The elimination of tubing not only helps to reduce weight, but it also eliminates the flammable liquids from the cockpit area.

Such systems give the pilot a constant report of the events that are happening at points throughout the aircraft. Signals are transferred from these points to instruments in the cockpit. The signals are transmitted over wires that run from a transmitting device located at the point where the pressure or movement is measured to the indicating unit.

There are several types of remote indicating systems that are categorized as self-synchronous. Such systems are often known by trade names such as autosyn and selsyn.

In this section, we shall discuss such self-synchronous systems as a position-indicating system, a fluid flow system, and a liquid quantity used in an indirect reading indicator. We shall begin with the basic components of a synchro system.

425. Identify operational characteristics of the synchro system by matching components/sections to their functions.

Basic Components of a Synchro System. A remote indicating system must consist of at least two basic components. Other components may be added, as you will see later in this section. One of the basic components, a transmitter, is located near the point where the pressure or movement is measured. This component actually measures and transmits the signal of that measurement to a

second component (the indicator) in the cockpit. The indicator receives a signal from the transmitter and converts it to a numerical value. This value then can be read directly from the indicator dial. Now that you have an idea of the components that make up a synchro system, let's discuss a typical synchro pressure system. Refer to figure 3-4.

Transmitter. This component has two sections: a mechanical sensing section and an electrical transmitting section. The mechanical sensing section may contain a diaphragm, a bellows, or a bourdon tube sensing device. The type of sensing device used will depend upon the type and range of pressure to be measured. The system that we will discuss will be a typical pressure system. The mechanical section is nearly the same as the one in a direct-reading pressure gage. In the gage, the pressure is applied to the bourdon tube assembly. The resulting movement is transferred to a sector gear by mechanical linkage. In the synchro transmitter, the bourdon tube mechanism operates basically the same as in a gage. There is, however, one exception. Instead of the sector gear's turning a pointer shaft, as it does in the gage, it turns a rotor in a synchro unit.

The electrical section of the synchro transmitter contains the synchro unit and the electrical connector. The synchro (autosyn) is much like a small motor or generator. The major parts of the synchro unit are known as the rotor and stator. The rotor consists of two small coils of wire wound around a common core. The core is part of the shaft. The rotor is installed in ball bearings. The bearings are pressed into the ends of the synchro housing. The rotor is mounted in such a way that it is free to rotate through 360° within the stator coils. The stators are press-fitted into the synchro housing.

Indicator. The indicator is the second major component of the system. It is located in the cockpit and connected to the transmitter by electrical wiring, and it consists of a synchro that is nearly identical to the synchro of the transmitter. The difference is that the rotor is positioned by the electrical signal applied to the stator from the transmitter. This arrangement prevents any drag on the rotor, permitting it to turn freely. Also, a pointer is attached to a rotor shaft that extends to the front of a calibrated dial. This gives the pilot a visual indication of the changes that occur in the system. An electrical connector on the back of the indicator connects it to the transmitter.

Exercises (425);

1. Identify the operational characteristics of the synchro system by matching system components/sections listed in column A with their functions listed in column B. Write the correct letter in the space provided. Some

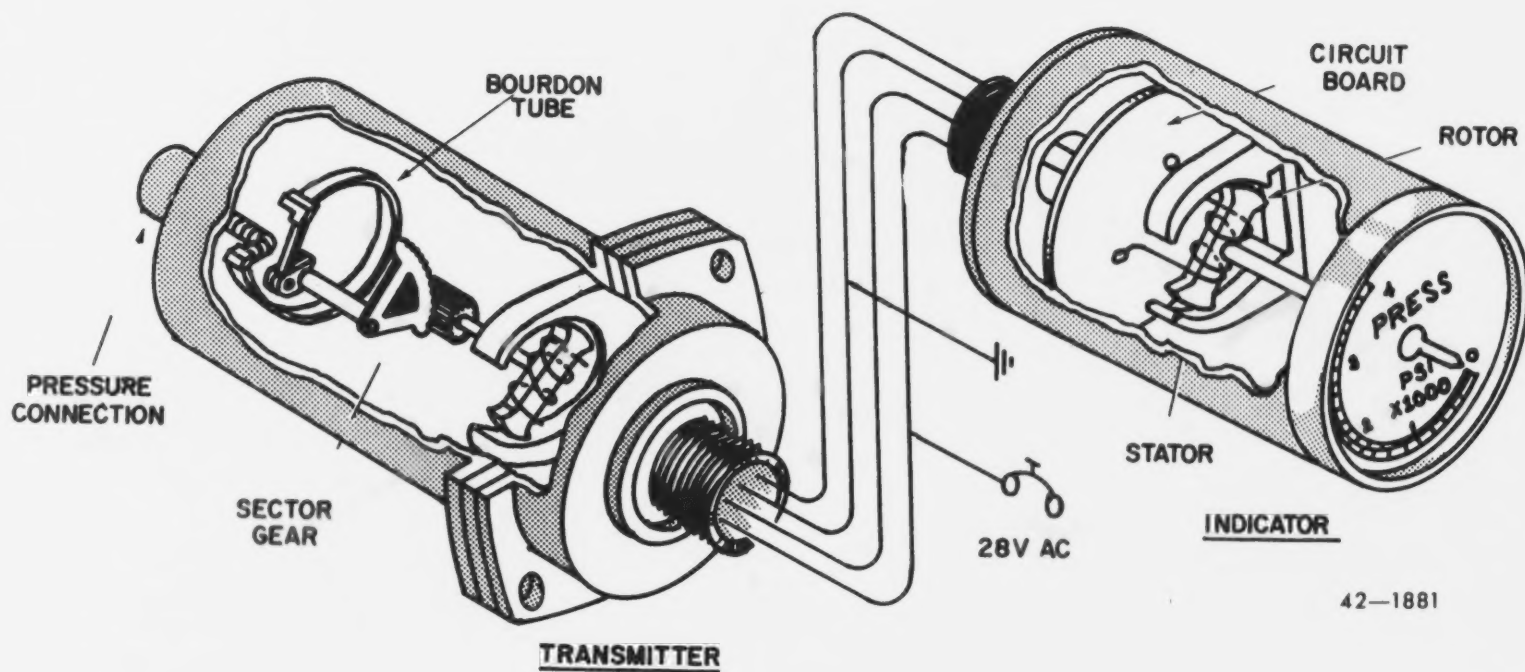


Figure 3-4. Synchro system.

functions are not used, and some are used more than once.

Column A Components/Sections	Column B Functions
— (1) Indicator.	a. Moves 320° within the stator coils.
— (2) Transmitter.	b. Turns a pointer.
— (3) Rotor.	c. Positions the rotor electrically.
— (4) Stator.	d. Lights a warning light in the cockpit.
	e. Sensing device.
	f. Located in cockpit.

426. Referring to a given schematic, specify the operation of the components of a position-indicating system.

Position-Indicating Systems. Position-indicating systems are installed on the aircraft to monitor the position of flight controls and other adjustable or moving controls. The position-indicating systems are necessary because the positions of the controls are not always observable by the pilot. Some of these controls (the landing gear, for example) have but two operating positions. In this case, the pilot must not only know the position of the gear, he must also know if the gear is locked in its proper position. Other controls have a wide range of intermediate operating positions. The leading and trailing edge flaps fall into this category. Yet, even here, the pilot must know their exact positions for safe operation of the aircraft. Position indicators are an extremely important group of the aircraft's instrumentation.

You will find position-indicating systems used to show the position of the landing gear, wing flaps, trim tabs, cowl flaps, and various other systems.

Most of the systems are based upon the selsyn principle. The word "selsyn" is derived from the term "self-synchronous."

We will use the wing flap position-indicating system to describe the selsyn system. This system typifies the selsyn principle. Two units make up this system. They are an indicator and a transmitter mounted on the flap gearbox. A shaft extending from the transmitter connects mechanically to the flap drive system. When the flaps move, this shaft rotates. Wires connecting the transmitter and indicator carry the electrical currents which drive the pointer shaft on the indicator through the same number of degrees that the transmitter shaft rotates. Since both shafts rotate in synchronization, the system is said to be self-synchronous. To get a general understanding of the system's operation, let's closely examine the units.

Transmitter. The transmitter consists of a circular resistance winding with three taps 120° apart. Notice in figure 3-5 that the two wipers mounted on the transmitter shaft make electrical contact with the resistance winding at points that are 180° apart. These wipers are rotated by transmitter shaft movement. One of the wipers is connected to the DC bus. The other wiper is connected to the aircraft ground through the transmitter case.

Indicator. The electrical mechanism of the indicator is a coil connected by wiring to the transmitter. Figure 3-5 is a schematic of the electrical system. Voltages that vary with the position of the transmitter wipers cause electrical currents to flow in the indicator field coils. The currents through two adjacent coils in the indicator are flowing in such a direction as to set up opposing fields in the laminated ring. As a result, instead of the flux going around the ring, it is

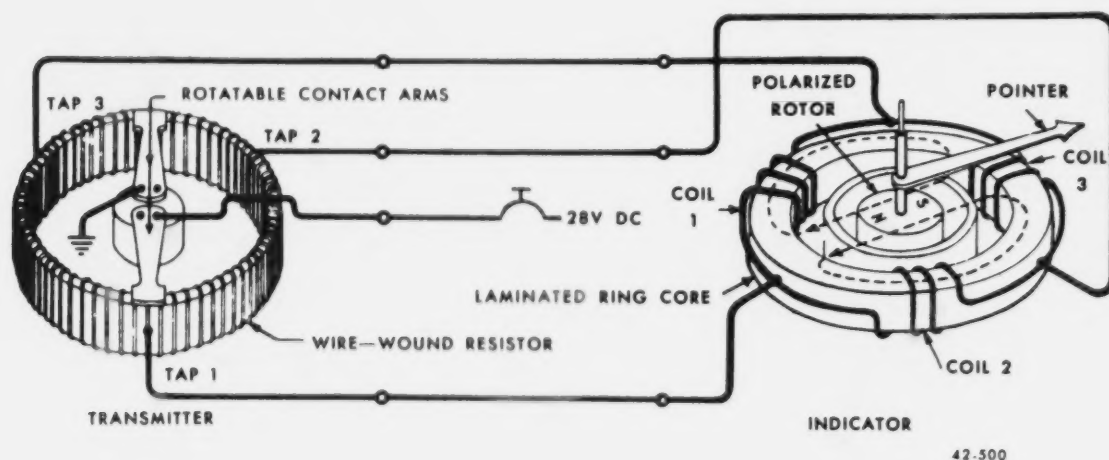


Figure 3-5. Position indicating system.

forced out of the ring. It must cross the inside space. The path of the flux is shown by the dotted lines through the indicator in figure 3-5. As the voltage at the transmitter taps is varied, the distribution of current in the indicator coils is affected. The direction of the magnetic field flowing across the indicating element is changed. As the magnetic field changes direction, the polarized (permanent magnet) rotor follows it. There are no springs or restraining forces on the rotor. Its movement is independent of the power source voltage. Likewise, since the coils are arranged symmetrically, the rotor position is not affected by the changes in coil resistance occurring with changes of temperature. How accurately the polarized rotor will follow is dependent upon the accuracy of the spacing of the coils and taps. Therefore, the transmitter and indicator in the system must be matched. Many indicators and transmitters are identical in their outward appearance. Their part numbers must be carefully checked to avoid mismatches.

System Operation. So that you will better understand the operation of the selsyn system, let's assign some voltages to the units shown in figure 3-5. You should be able to see that, if 28-volt DC power is applied to the power contact arm, the voltage must be dropped between the power contact arm and the ground contact arm. With the contact arms positioned as shown in figure 3-5, tap 1 of the transmitter resistance strip would be at a 28-volt potential. The ground contact arm would be at a 0-volt potential. Since tap 2 of the resistance strip is about one-third of the distance between the ground contact arm and the power contact arm, about one-third of the distance between the ground contact arm and the power contact arm, about one-third of the applied voltage will be dropped at tap 2. The same condition will apply to tap 3. This means that the voltages felt at the taps will be as follows: tap 1, 28 volts; tap 2, 9 volts; and tap 3, 9 volts.

Study figure 3-5. Notice that the wires connected to the taps of the transmitter resistance strip are also connected to points between each coil of the indicator. Follow the wire connected to tap 1 across the diagram to where it connects between coil 1 and coil 2 of the indicator. You will see that the 28-volt potential from tap 1 of the transmitter will be present at this point. Now follow the wires connected to taps 2 and 3 of the transmitter, and you will see that the same 9-volt potential of these taps will be applied to these points between the indicator coils. With these potentials applied to the indicator coils, let's see what happens. Because both ends of coil 3 are at the same potential (9 volts) no current will flow in coil 3. However, a difference in potential exists across coil 1 and coil 2, (the difference between 9 volts and 28 volts). Because of this, current will flow through coils 1 and 2 from the 9- to the 28-volt potential. This creates the

magnetic field represented by the dotted lines in figure 3-5. The permanent magnet rotor will align with this field. This causes the pointer to show the position of the wing flaps. As the contact arms are repositioned to show the position of the wing flaps. As the contact arms are repositioned on the resistance strip, the voltage changes will create a magnetic field change in the indicator. This change in magnetic field direction will cause the pointer to show the new position of the wing flaps.

Exercises (426):

1. Briefly describe the main electrical unit of a selsyn position transmitter.
2. What causes the pointer of a selsyn indicator to move?
3. Referring to figure 3-5, how much of the applied voltage is dropped between tap 2 and the ground-contact of the position transmitter with the transmitter wiper as shown?
4. Referring to figure 3-5, assume that the transmitter wiper power contact moved around the resistance strip to align with transmitter tap 2. State the direction in which the indicator pointer would point.

427. Specify the operation and constructional features of fluid flow transmitters.

Fluid Flow Measuring System. Fluid flow systems measure the rate of flow rather than the pressure. This rate of flow is indicated by gallons per minute (gpm) when used with hydraulic fluids, and pounds per hour (pph) when used with fuel flow. Because the GPM is not monitored on an aircraft, but rather is used on ground power equipment, we will limit the information to a fuel flow system similar to those found on inflight refueling systems. The basic principles are the same, however, for both systems.

You will find many types of fuel flow transmitters being used on today's aircraft. Even though their construction and appearance may differ, their operation is fundamentally the same. You understand, of course, that the transmitters must have some means of measuring the amount of fuel flow for a given period of time. This measurement occurs as the fuel flows through the transmitters. There are two connecting ports on the

transmitter, clearly marked with arrows to show the direction of flow through the transmitter.

Figure 3-6 shows a breakaway illustration of a single-synchro transmitter. The path of flow through the transmitter is shown by heavy black arrows. Notice that the fuel enters through the port facing you. Once inside the transmitter, the fuel flows through a chamber (E) called the metering chamber. The fuel then exits through the port away from you. As the fuel flows through the metering chamber, it applies force to the moveable metering vane (F). Notice also in figure 3-6 that the metering chamber is not concentric in design. Because the chamber is not concentric, you can see that, as the displacement of the vane increases, the area through which the fuel flows also increases. As more fuel flows through the transmitter, more force is exerted on the moveable vane; thus, the displacement of the vane becomes greater.

Notice in figure 3-6 that the movement of the vane is restrained by a calibrated vane restraining spring (G). This spring dampens the movement of the vane and returns the vane to the NO FLOW position when the fuel flow stops. Attached to the opposite end of the vane shaft is a ring-shaped magnet (D). This magnet will rotate anytime the vane moves. The moveable vane, calibrated spring, and ring-shaped magnet are all sealed within the fuel metering chamber.

Because the fuel-measuring section of the transmitter must be kept separated from the electrical section, a fuel-tight seal is placed over the ring-shaped magnet. This fuel-tight seal also contains the mounting frame for the synchro unit (B). How is the rotor of the synchro unit moved, since we have sealed off the vane shaft? Look at figure 3-6. You will see a bar magnet (C) attached to the rotor shaft of the synchro unit. This arrangement is called a magnetic coupling. Even

though a thin metal seal separates the two magnets, the bar magnet will align itself with the magnetic field of the ring magnet. When the ring magnet is rotated by the moveable vane shaft, the bar magnet is repositioned and turns the rotor of the synchro unit. Depending upon the type of transmitter, the magnets previously discussed may be reversed. That is, the ring magnet may be mounted on the synchro rotor shaft while the bar magnet may be mounted on the vane shaft.

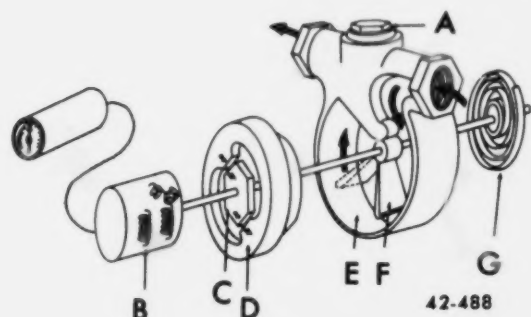
As a safety precaution, the transmitter is equipped with a bypass relief valve (A). The valve is of the spring type and will open any time the rate of flow exceeds the flow limits of the transmitter. This valve allows fuel to bypass the measuring section and reach the engine should the moveable vane become stuck.

The synchro unit is attached to an indicator. The synchro unit operates the same as the synchro units previously discussed. The only significant difference is that the indicator dial is calibrated in pounds per hour instead of psi.

Exercises (427):

1. What is the purpose of the calibrated vane restraining spring in a single-synchro fuel flow transmitter?
2. The rotor of the synchro unit is positioned in a single-synchro fuel flow transmitter by a _____.
3. The bypass relief valve in the fuel flow transmitter is necessary in the event the _____.
4. What is the significant difference between the indicator in this system and others previously discussed?

428. Specify the operation of a typical liquid quantity indicating system.



- | | |
|------------------------|-----------------------|
| A. Bypass relief valve | E. Fuel flow chamber |
| B. Synchro unit | F. Metering vane |
| C. Bar magnet | G. Restraining spring |
| D. Ring-shaped magnet | |

Figure 3-6. Fuel flow transmitter.

Liquid Quantity (Level) Indicating System. Back in the old days, when an airplane resembled a boxkite, the oil quantity indicator consisted of a dip stick poked into the tank. As aircraft became more sophisticated, some other means of indicating the fluid level became necessary. Figure 3-7 shows a simplified wiring schematic of a liquid level system. This system is also referred to as a float type liquid

level indicating system. The components required in this system are an indicator and a reservoir transmitter. These two units are connected by electrical wiring and operate off 28 VDC power. Inside the reservoir is a float that moves up and down with the level of fluid in the reservoir. The transmitter is made up of a resistance strip and a wiper arm. The wiper arm will move across the resistance strip in relation to the float movement in the reservoir. The indicator consists of a permanent magnet attached to the pointer. This pointer is placed between two stationary coils of wire.

Now that we know the basic units in this system, let's see how it operates. As the float inside the reservoir shown in figure 3-7 moves up, the wiper arm on the transmitter moves up on the resistance strip, thereby decreasing the resistance of the strip. Now trace electrical current flow from the ground on the transmitter wiper through the resistance strip to coil A. From coil A, current flows to the 28 VDC bus. The decreased resistance of the resistance strip increases the amount of current flowing through coil A. This increase in current will strengthen the electromagnetic field of coil A and attract the permanent magnet on the indicator to it. As the permanent magnet moves toward coil A, it moves the pointer, indicating the increase in fluid level in the reservoir.

Exercises (428):

You may use figure 3-7 to help you answer these questions.

1. As the fluid level in the reservoir lowers, what will happen to the transmitter wiper?
2. If both coils A and B have the same magnetic strength, what will happen to the pointer?
3. If the pointer is indicating 2 gallons, which coil has the stronger electromagnetic field?

429. Specify the constructional and operational features of an electrical differential pressure indicating system.

Electrical Differential Pressure Indicating System.

Today's modern day aircraft use a differential pressure indicating system for a number of different reasons. One use could be to isolate a defective unit in a hydraulic power supply system by sensing the pressure entering and leaving the unit. If a difference in pressure exists the indicating system could be used to turn on a system failure light, alerting the crew to switch to another hydraulic power supply. It could also activate a computer that will automatically switch to another hydraulic power supply, record the information in its memory bank for future use, or supply the ground maintenance crew with a taped printout of the

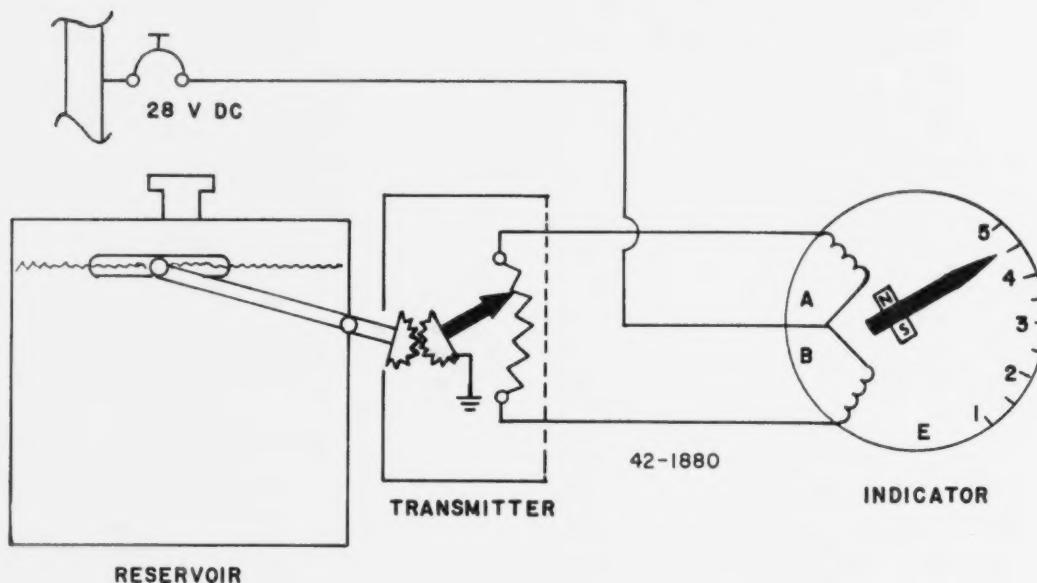


Figure 3-7. Fluid quantity indicating system.

maintenance problems. A simple electrical differential pressure indicating system is shown in figure 3-8. It consists of two basic units, the transducer and the indicator. Its theory of operation is used on all the differential pressure indicating systems in use today.

Transducer. Generally speaking, a transducer is any device which changes one type of signal to another. Figure 3-8 shows a simplified schematic of one type of transducer. Notice that it has two ports with a diaphragm between them. Mechanically attached to the diaphragm is a contact arm that will move up or down on a resistance strip (resistor). This resistance strip will send an electrical signal to an indicator.

Indicator. The indicator used in the electrical differential pressure system is similar to the ones discussed earlier in this chapter. The difference will only be in what is indicated on the dial, quantity, or pressure. In some cases, the indicator could be a warning light rather than a gage.

Operation. The operation of this system depends upon movement of the transducer diaphragm. Pressure, which can be the pressure entering a filter assembly and the pressure leaving the filter, is applied to both sides of the diaphragm. Any increase or decrease in the pressure differential across the diaphragm will result in the movement of the diaphragm. This latter movement will cause a corresponding movement of the wiper arm across the resistance strip. Movement of the wiper arm across the resistance strip changes the amount of current flow to the indicator. The change in current flow results in magnetic fields of different strength around the coils. The final result, then, is a change in the permanent magnet rotor position. The rotor in the indicator will assume a new position with each movement of the wiper arm.

Exercises (429):

1. Define a transducer.
2. The transducer in figure 3-8 measures _____ in pressure.
3. What separates the two pressure ports of the transducer?
4. What are the two basic units in the differential pressure indicating system?
5. The transducer converts differential pressure into an _____ signal.

430. State the purpose and specify the constructional features of a pressure switch. Then, using figure 3-10, indicate whether given statements correctly reflect the operation and use of the pressure switches.

Pressure Switches. A pressure switch is nothing more than a switch that is actuated by pressure. They are used in hydraulic systems with electrically driven pumps to maintain the system pressure within set limits. They can also be used in hydraulic systems to control the operation of warning and protective devices. Pressure switches come in

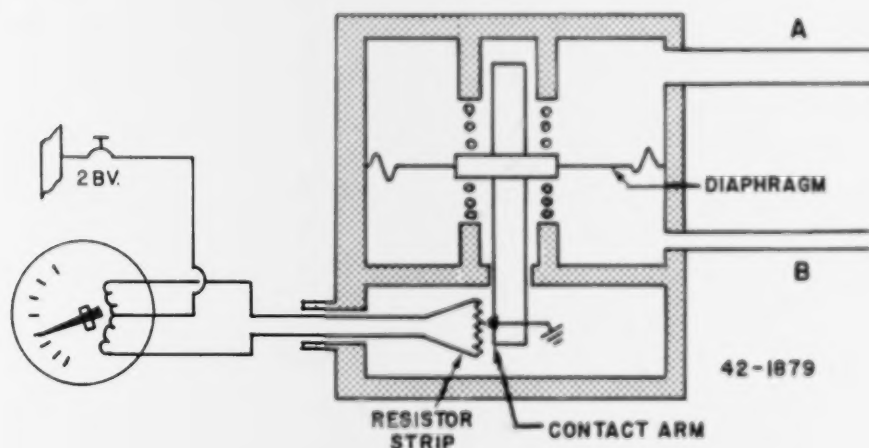


Figure 3-8. Differential pressure indicating system.

various types. Figure 3-9 shows the bourdon tube type (A), the bellows type (B), and the piston type (C). Even though the construction is different, the principle of operation of each of these pressure switches is essentially the same. Each type has some device which holds a set of electrical contacts to either the "open" or "closed" position. It has a hydraulic pressure port and an electrical connection.

Bourdon tube. Since we have already discussed the bourdon tube previously, we will not spend too much time on this type of pressure switch. As pressure enters the bourdon tube, it straightens out the tube. In this case (see fig. 3-9), as the tube straightens out, it breaks the contacts of the electrical switch.

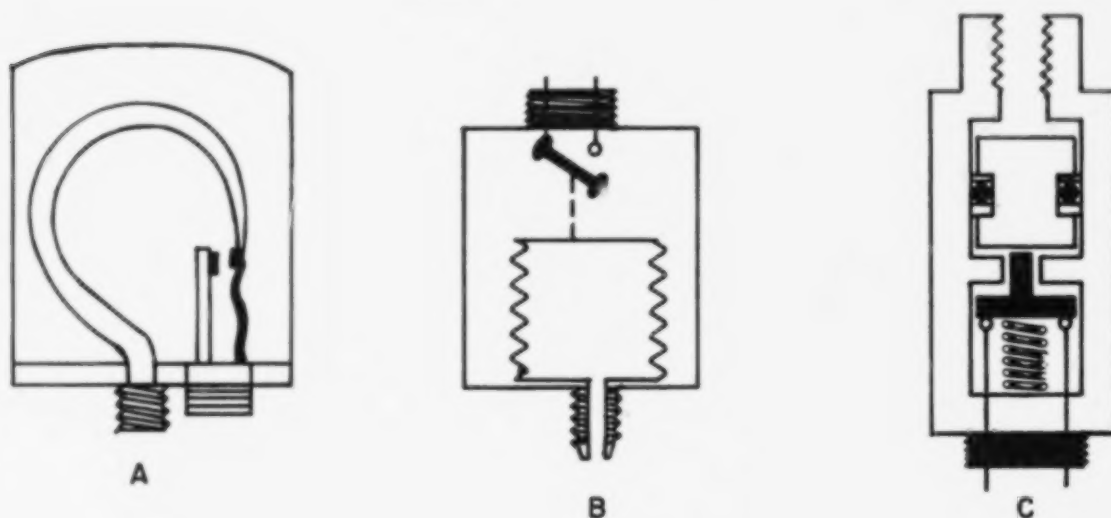
Bellows. The bellows is made of a material, usually thin copper, folded in an accordion shape. As pressure enters the inlet port, it exerts a pressure on the inside of the bellows. This causes the bellows to stretch. Mechanically attached to the bellows is an electrical switch. In this case, as the pressure builds up, it pushes the switch to make contact and complete the circuit. As pressure is reduced, the bellows returns to its original shape, breaking the contacts of the electrical switch.

Piston. As pressure enter the inlet port, it pushes the piston down, overcoming the spring tension of the switch spring. The piston does not have to move very much, just enough to make or break the switch contacts. Notice that the piston cannot move down all the way because the housing prevents it. Also notice that the piston has an O-ring seal to prevent fluid from leaking past it. As the pressure is reduced in the inlet, line, the spring under the

switch pushes the contacts off seat and pushes the piston up against the upper stop of the housing.

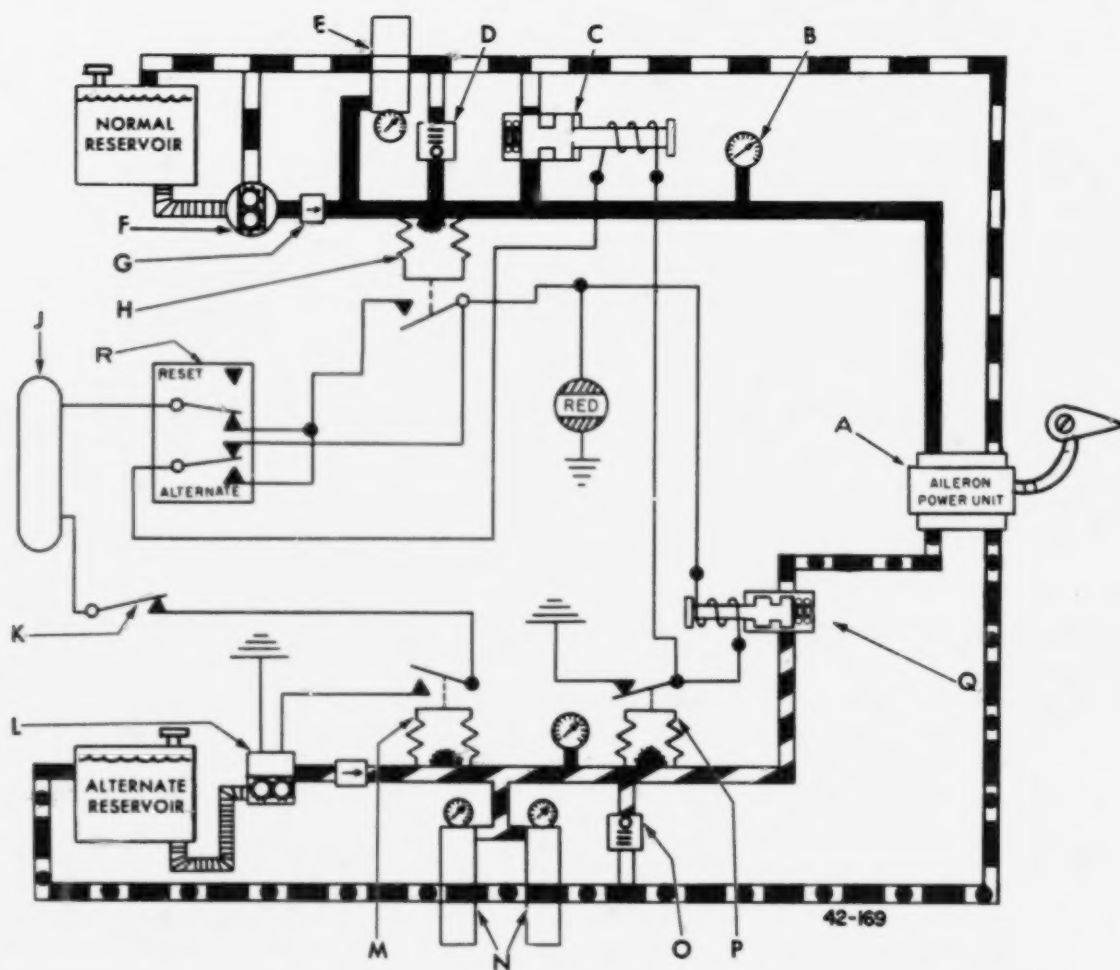
Operation. With the help of figure 3-10, let us see how pressure switches can be used to indicate malfunctions and, at the same time, be used to maintain system pressure. Item A represents a flight control power control unit attached to a flight control surface (aileron, rudder, elevator). To operate this power control unit, two separate systems are used—one system normally operated from an engine-driven pump (F) and the alternate system operated from an electrically driven pump (L). In the normal position, the normally system bypass valve (C) is held in the closed position by a spring. Fluid from the engine-driven pump (F) flows through a check valve (G) to a pressure switch (H), to a relief valve (D), to a normal system accumulator (E), and down to the power control unit (A). As long as the normal system pressure is available, the system will function normally.

Now let's see what happens when the normal system pressure drops and when pressure switch (H) is closed. Electrical current for system operation is supplied by the bus (J). From the bus, current goes to the upper set of contact points on the control switch (R). The pressure switch (H) has closed its electrical contacts and now provides a path for current flow back to the lower set of contact points on the control switch (R). From the lower set of contact points, current goes through the bypass valve (C) to ground through a pressure switch (P). Using the pressure switch (P) as the path to ground makes sure that changeover cannot be made unless there is ample pressure in the alternate system. Now, the normal system bypass



42-1893

Figure 3-9. Types of pressure switches.



- | | |
|--|--|
| A. Power control unit (aileron) | K. Alternate system manually operated switch |
| B. Normal system pressure gage | L. Alternate system pump |
| C. Normal system bypass valve | M. Alternate system pump pressure switch |
| D. Normal system relief valve | N. Alternate system self-displacing accumulators |
| E. Normal system self-displacing accumulator | O. Relief valve |
| F. Engine-driven pump (for normal system) | P. Alternate system pressure switch |
| G. Check valve | Q. Alternate system shutoff valve |
| H. Normal system pressure switch | R. Control switch |
| J. 24-volt bus | |

Figure 3-10. Pressure switch controlled system.

valve (C) is energized open, and it vents all remaining pressure in the normal system to the normal return line. At the same time, a circuit starting at the closed normal system pressure switch (H) energizes the red warning light and sends electrical current to the alternate system shutoff valve (Q). The electrical current will flow through the alternate system shutoff valve (Q) to the ground created by the closed pressure switch (P). With the alternate system shutoff valve (Q) now open,

pressure from the alternate system can flow to the power control unit (A) to operate the flight controls.

An alternate system pump pressure switch (M) is used to regulate the pressure in the alternate system. It controls the circuit to the alternate system pump motor through normally closed switch (K). This switch can be turned off at will. Notice in figure 3-10 that the alternate system pump pressure switch (M) is open. Because of this, the alternate

system pump (L) is not running. Alternate system pressure, however, is available in the lines and the accumulators (N). If the alternate pressure should drop off slightly, the pressure switch (M) would close and send current to the pump motor (L). When the pressure again builds up to the desired value, the electrical contacts on the pressure switch (M) will be broken. Through the opening and closing of this pressure switch, alternate system pressure is maintained at a predetermined setting.

The lower switch in the control switch (R) can be placed in the alternate position whenever manual changeover is desired. Let us assume that you wish to check the alternate system to see if it is operating properly. The normal system pressure switch (H) is normally open, so you must in some way bypass this switch to perform the test. This bypass must complete a circuit around this open pressure switch (H). Placing the control switch (R) to the alternate position will complete the bypass. With the control switch placed in the alternate position, current flows from the bus bar to the upper switch. From the upper switch, it flows through the lower switch, and then to the normal bypass valve (C). From the bypass valve (C), it goes through the closed contacts of the alternate system pressure switch (P) to ground. When this happens, the normal system bypass valve (C) opens and allows the normal system pressure to be dumped into the normal system return. When the normal system pressure

switch (H) closes, the circuit to the light and the alternate system shutoff valve is completed, thus completing the changeover. To change back to normal system, you must return the lower control switch to its normal position and then momentarily raise the upper control switch to the reset position. The reset position merely breaks the circuit to all of the electrical units and allows them to spring back to their normal closed position.

Exercises (430):

1. What uses can a pressure switch be put to in a hydraulic system?
2. How and of what is the bellows in a bellows type pressure switch usually made?
3. What purpose does the spring in the piston type of pressure switch serve?
4. What is used in the piston type of pressure switch to prevent hydraulic fluid from leaking past the piston?

Use figure 3-10 for the following exercises. Indicate whether the following statements correctly reflect the operation and use of the pressure switches in a typical flight control system by placing a T in the blank if it is true or an F if it is false. Correct statements that are false.

5. When normal system pressure is available, pressure switch H is open.
6. When alternate system pressure is available, pressure switch M is closed.
7. When pressure switch H is closed, the red warning light will come on and the alternate system shutoff valve will open.
8. The normal system pressure switch (H) will close its electrical contacts when the pressure in the normal hydraulic system is low.
9. The alternate system pressure switch (P) turns the alternate system pump on when the system pressure is low and turns it off when the system pressure is at the required level.

431. State how heat affects metal, and specify the purpose and constructional features of a thermal switch.

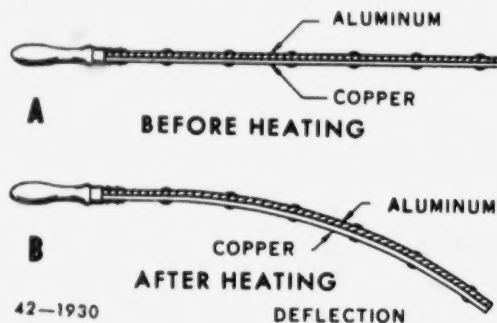
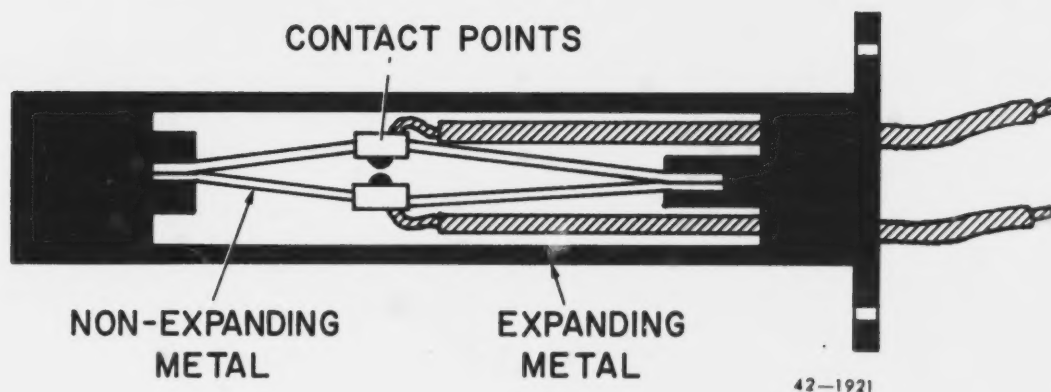


Figure 3-11. Bimetallic strip.



42-1921

Figure 3-12. Thermal (temperature) switch.

Thermal expansion of metals. When heat is applied to any metal or metal alloy, the material will expand. The amount of expansion depends on the specific type of metal involved. For example, assume that two different metals, in this case aluminum and copper, are fastened together as illustrated in figure 3-11, A. This device is called a bimetallic strip. As long as the initial temperature is maintained, the bar will remain flat and unbent. However, when the temperature rises, the metallic strip will bend as shown in 3-11, B. The reason for this is that aluminum will expand faster than copper. Although this expansion may create problems in some cases, it also has practical values. Selected metals allow aircraft designers to obtain the deflection desired for operation of various components. As an example, the addition of electrical contacts on a bimetallic strip will allow the device to open and close circuits at a predetermined temperature. We call this device a thermal switch.

Thermal switches. Thermal switches are heat-sensitive units that complete or break an electrical circuit when they are exposed to certain temperatures. They are used primarily in the pneudraulic systems as warning devices. As an example, they could be used to warn that the hydraulic fluid is excessively hot. Figure 3-12 shows the internal construction of a simple temperature switch. This switch is constructed with two contacts mounted on nonexpanding strips. Two electrical

wires are attached to the contacts. One wire goes to the top contact, and the other wire to the lower. The contacts are mounted in a seamless brass or stainless steel outer tube that has a high expansion rate. When this type of temperature switch is subjected to heat, the outer tube will expand, thus increasing the overall length. As the outer tube is stretched outwards, it has a tendency to pull the two contacts together, thus completing an electrical circuit.

Exercises (431):

1. What happens to metal when heat is applied?
2. Why does the bimetallic strip shown in figure 3-11, B, bend when heat is applied?
3. Which part of the temperature switch expands?
4. Why are temperature switches used in pneudraulic systems?

Selector Valves and Actuators

THE HYDRAULIC fluid pressure from one power supply system can be used by a number of different systems, such as landing gear, brakes, wing flaps, flight controls, and nosewheel steering. How would you feel as the pilot of an aircraft if, when you wanted the aircraft to bank to the right, the landing gear extended instead?

Yes, the hydraulic fluid pressure that is received from the hydraulic power supply system must be controlled and directed to make sure it goes to the proper system. In addition, for the hydraulic fluid pressure to do work, the pressure must be converted to mechanical energy.

In this chapter, we will cover those units that control and direct the hydraulic fluid to its point of use, along with the actuating units that convert it to some other form of energy. Section I will cover the selector valves, from manual to solenoid-operated. Section II will cover actuating units, such as actuating cylinders and hydraulic motors.

4-1. Selector Valves

Just as a traffic cop must control and direct the flow of traffic through an intersection, a selector valve (see fig. 4-1) must control and direct the flow of hydraulic fluid. Selector valves are also given the names "directional control valves" and "control valves." The type of selector valves used in a system depends upon the type of system, the type of actuators, and the manufacturer's desires. Some of the selector valves that will be covered in this section are the manual, the solenoid, and the more modern servo control valve.

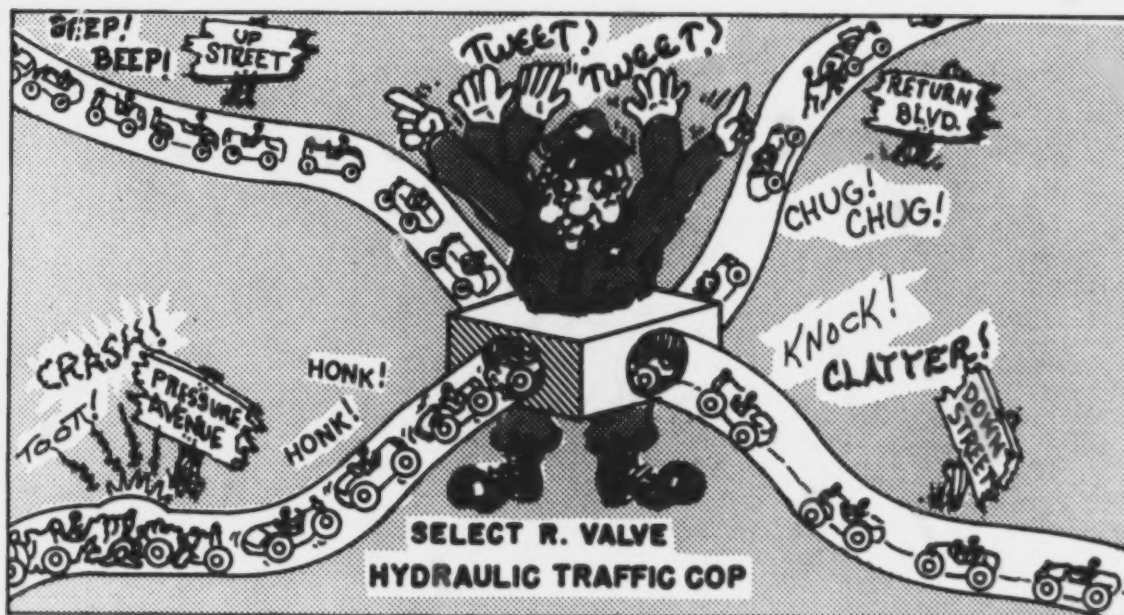
432. Specify constructional and operational features of a poppet and slide manual selector valve.

Manual Selector Valves. Even though you may not find as many manual selector valves as you could have found in years past, these valves are still found on many of today's modern aircraft in such areas as the flight controls and nosewheel steering. To cover each and every type of manual selector valve is beyond the scope of this course, so we have

selected two types that are common, yet are different in construction and operation. The two that we have chosen are the poppet type and the slide type.

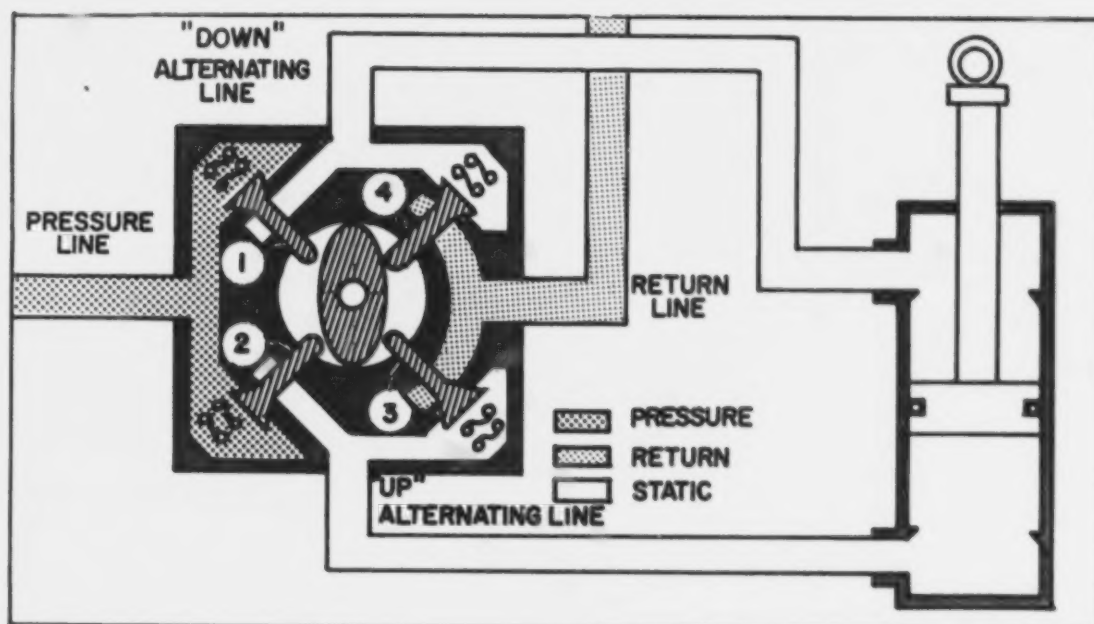
Poppet. Figure 4-2 illustrates a typical four-port poppet selector valve. This valve has four ports—one pressure, two alternating, and one return. The valve has four spring-loaded poppets that are enclosed in a common housing and are interconnected by passageways. The poppets are actuated by a cam, which is connected to an external shaft (not shown). The poppets are arranged so that the rotation of the cam will open the proper combination of poppets to direct the flow of fluid in the desired direction. This valve has three positions—one neutral and two working positions. In the neutral position, as shown in figure 4-2, the lobes on the cam are not contacting any of the poppets. With all poppets on seat, there is no flow of fluid through the valve. This also blocks the two alternating ports, trapping the fluid in the alternating lines to the actuator. By moving the camshaft handle 45° in either direction from neutral (see fig. 4-3), you can cause the lobes of the cam to unseat one pressure poppet and one return poppet. The valve is now in a working position. Fluid entering the pressure port travels through poppet 1 and out into the down alternating line to the actuator. Return fluid coming from the actuator is routed through poppet 3, through the valve, and out to return. If the cam is rotated 90° , poppets 2 and 4 will unseat, and poppets 3 and 1 will seat. This will allow the fluid entering the pressure port to be routed through poppets 2 and 4 in much the same way as the previous poppets. If the cam is rotated 45° to the left, the lobes of the cam will not push the poppets off seat, and the selector valve will return to a neutral position.

Slide. The slide selector valve requires only a short movement of the linkage to the selector valve to actuate it. One of the major advantages of this type of valve is its metering ability. It does not have to be positioned all the way open. For this reason, a mechanism can be operated at varying speeds. The rate of fluid flow going through the valve can be controlled. Frequently this valve is called a metering valve.



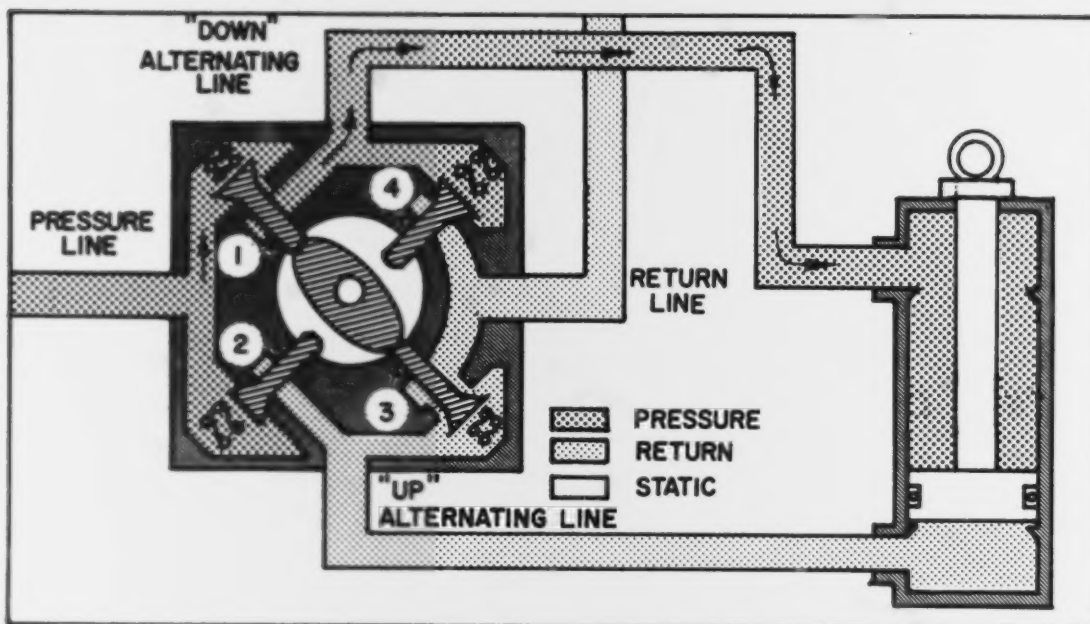
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Figure 4-1. The hydraulic traffic cop.



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Figure 4-2. Manual poppet selector valve (neutral position).



42-1910

Figure 4-3. Manual poppet selector valve (working position).

Figure 4-4, position 1, shows the metering valve in the neutral position. Fluid under pressure fills the space between the ends of the sliding spool (D). Because the alternating ports (C and E) are closed, the fluid is trapped. Position 2 shows the slide (D) moved to the right. This allows pressure from the pressure port (A) to enter the right-hand alternating line (E). The other alternating port (C) is connected to the return manifold through the return port (B). Position 3 shows the slide (D) moved to the left. This allows pressure to enter the left-hand alternating line (C). The other alternating line (E) now connects to the return port (B) through the drilled passageway across the top.

Exercises (432):

1. Which one of the manual selector valves can be used as a metering valve?
2. When the poppet selector valve is in neutral position, which poppets are on seat?
3. If the cam on the poppet selector valve is positioned 45° from neutral, what will happen?

4. Which valve should be used if the unit that is to be operated must be operated at varying speeds?

433. Specify the operation of a solenoid-operated selector valves.

Solenoid-Operated Selector Valves. Solenoids are electrical devices that can be used to position mechanical units. Solenoids permit us to position selector valves that are remotely located in the aircraft. Another advantage of electrical control is the removal of high pressure lines from the cockpit. Furthermore, much weight is saved by the reduction of the length of hydraulic lines.

Solenoid-operated selector valves differ from the manually controlled valves previously described in that they are electrically controlled by one or more solenoids contained within the valve. To demonstrate how a solenoid operated valve operate, we have selected two valves: the slide type and the poppet type.

Slide. Figure 4-5 shows a slide selector valve. The body has 4 ports; pressure, return, and two alternating ports. Inside the valve there are two slides (spools), which are centered within the valve by springs. The upper spool is called the pilot spool, and the lower one is called the control spool.

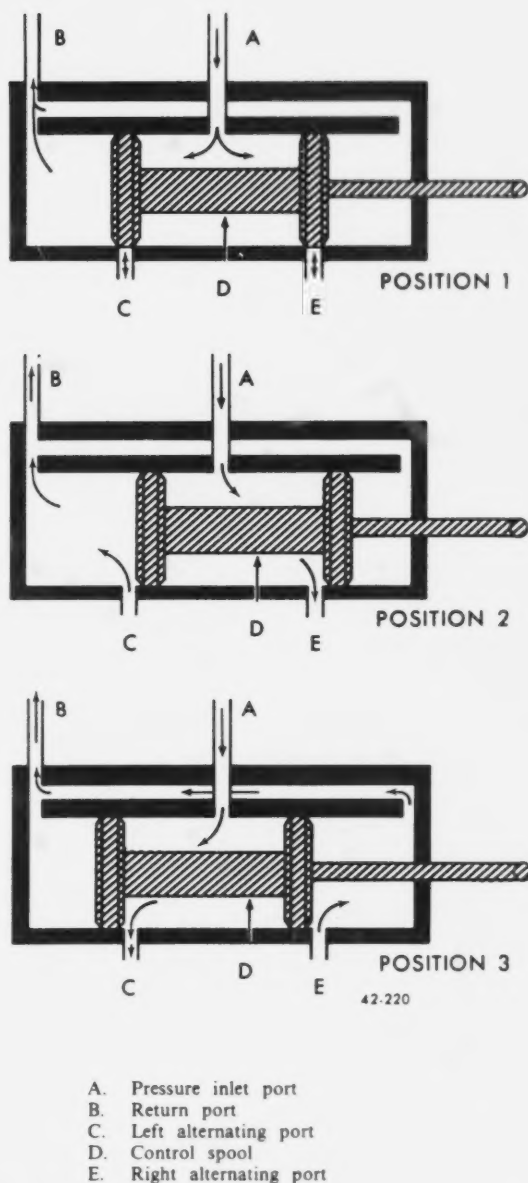


Figure 4-4. Manual slide selector valve.

Notice also that the slides (spools) have raised flat portions, called lands. These lands form a seal to separate the different passageways within the valve. When the slides are properly positioned, the lands will allow fluid to flow from one passageway to another. A solenoid, labeled 1 and 2, is installed on each side of the valve. They are made up of many turns of fine insulated wire; and, once energized, they possess the same properties as an electromagnet. Inside the solenoid is a plunger which reacts to the magnetic field created when the

solenoid is energized. As you can see, the plunger is connected to the pilot spool so that, when the solenoid is energized, it will position the pilot spool at the same time. Now that you understand the construction of the slide solenoid-operated valve, let's talk about its operation.

Three conditions or positions of the solenoid-operated selector valve are discussed below. These positions are the result of electrical energy's being directed to a certain part of the valve or being cut off from the valve entirely. They are the deenergized position, solenoid 1 energized position, and solenoid 2 energized position.

a. Deenergized position. With both solenoids deenergized, the valve is in the neutral position. (See fig. 4-5, A.) By observing the spools very closely, you can see that the pressure line is blocked off. Further examination will reveal that both return lines are open. In other words, fluid from both cylinder 1 and cylinder 2 can flow to return. Notice that the springs on either side of the pilot spool and the control spool are keeping the valve centered.

b. Solenoid 1 energized. View B of figure 4-5 shows the valve with solenoid 1 in the energized condition. Note that the pilot spool has moved to the left, compressing the spring. When the pilot spool is in this position, it allows fluid to flow from the pressure port down to the left side of the control spool. When pressure acts against the left side of the control spool, it is forced to move to the right, compressing the spring on the right side of the control spool. Notice now that fluid can flow from the pressure port, through the control spool, and out through the cylinder port 1. Fluid from cylinder port 2 can now flow through the valve and back to return.

c. Solenoid 2 energized. In view C of figure 4-5, solenoid 2 is in the energized condition. This of course reverses the pressure and return ports, allowing pressure to be exerted toward cylinder 2 and opening cylinder 1 to return.

Poppet. Another version of a solenoid-operated valve is illustrated in figure 4-6. It is basically the same except for some constructional features. Instead of a pilot spool, it has poppets, which are attached to the plunger in the solenoids. The control spool has three lands instead of four. The poppets will be positioned against what we will call the pressure seat and the return seat. Here again this valve will have three positions—deenergized, solenoid 1 energized, and solenoid 2 energized. Let's start with the deenergized position first.

a. Deenergized position. When the valve is deenergized, the poppets will be positioned as shown in figure 4-6, A. The poppets in this case are on seat against the return seats. Pressure can come down through the valve to the center land of the control spool. As you can see, it cannot go any farther; however, it can go to each end of the

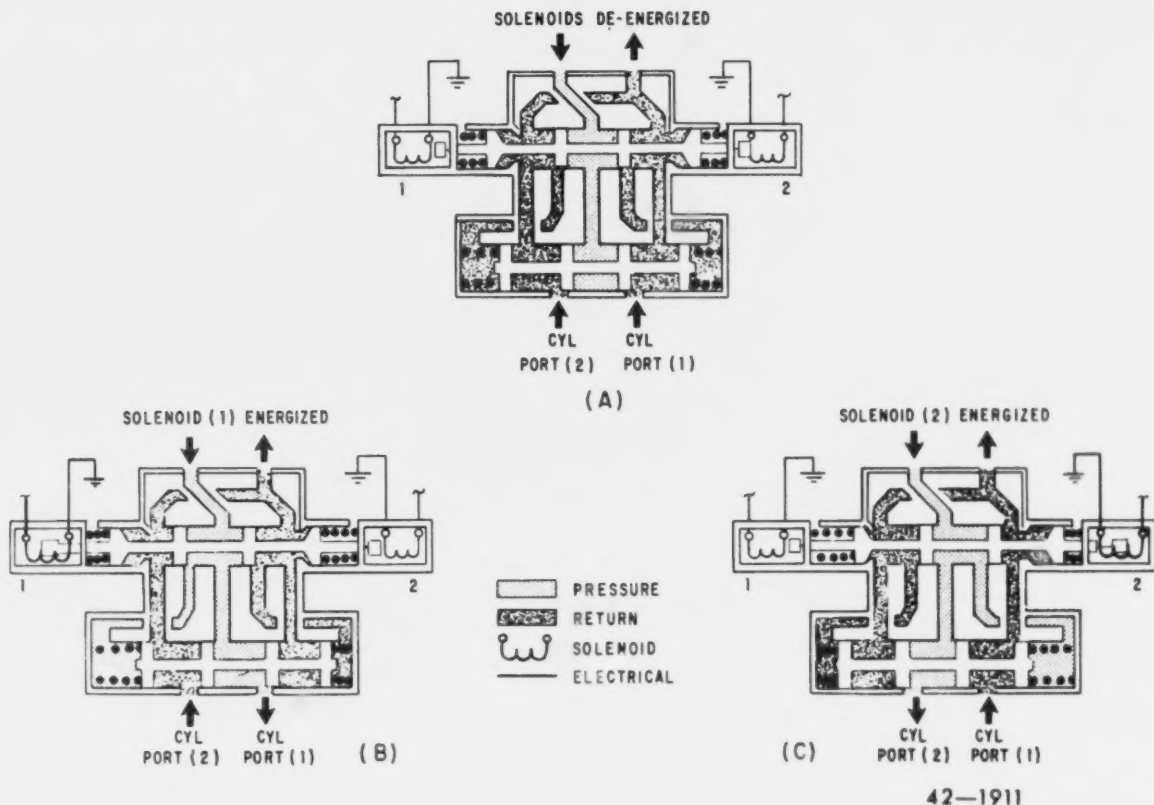


Figure 4-5. Solenoid-operated slide selector valve.

control spool. Now the springs and pressure acting against the control spool will keep it in the neutral position.

b. Solenoid 1 energized. When solenoid 1 is energized (see fig. 4-6, B), the plunger forces the left poppet to be forced on seat against the pressure seat. This then allows the return seat to open to return. Any fluid on the left side of the control spool then has a free path to return. Pressure entering the valve can flow to the right side of the control spool, thus pushing it to the left. Once the control spool has been positioned, it opens the right cylinder port to allow fluid to flow from the pressure port out to the alternating lines. Return fluid from the system can now flow from the system back through the control spool to return.

c. Solenoid 2 energized. In view C of 4-6, solenoid 2 is energized. This works basically the same as solenoid 1 energized except that the alternating ports are reversed.

Exercises (433):

Using figure 4-5 and figure 4-6, determine the operation of the slide and poppet type solenoid-operated selector valve.

1. When the slide control valve is in the deenergized position, can fluid flow from the pressure port to the alternating ports? Can fluid flow from the alternating ports to return?
2. What centers the control spools on either the poppet or slide selector valves?
3. When solenoid 2 is energized, in which direction does the pilot spool move in the slide selector valve?
4. Why are solenoid-operated valves used instead of manual valves?
5. Look at figure 4-6, C. Specify which poppet is on the pressure seat and which is on the return seat.

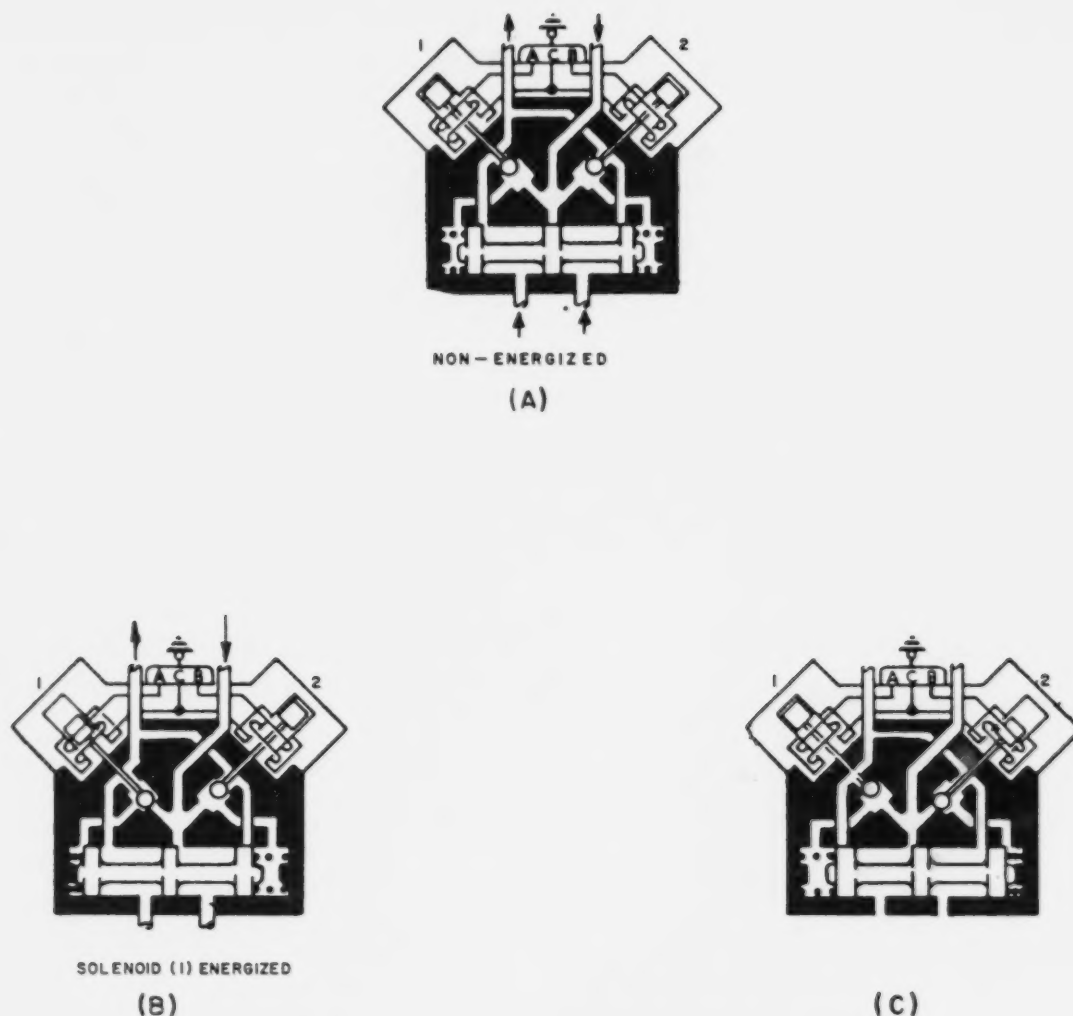
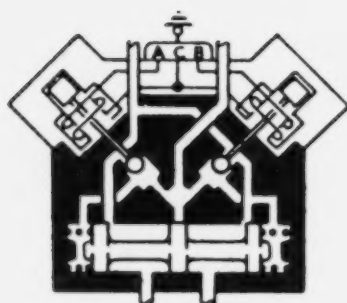


Figure 4-6. Solenoid-operated poppet selector valve.

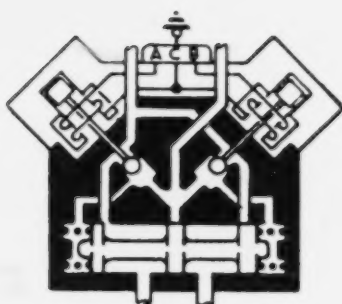
434. Define the terms "full trail, half trail, and non-trail" as they are used with reference to selector valves.

Terms "Full Trail, Half Trail, Non-Trail." When an actuating cylinder is positioned to a desired position, the selector valve is usually placed in the neutral position (nonenergized). let's say that we want to extend the speed brakes. Once the speed brakes are extended, the valve is placed in neutral. This is fine as long as the aircraft is on the ground, but in flight it is a different matter. If the air load acts against the speed brake doors, it will force the speed brakes to close. In other words, the fluid in the speed brake actuators and alternating lines will be forced back to the return through the selector valve by the air pressure acting against the speed

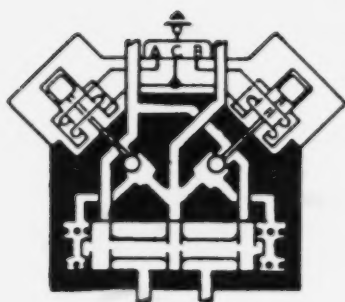
brake doors. To prevent this from happening, selector valves can be designed to trap fluid in the alternating lines to the actuators. In other cases, maybe we don't want to trap fluid in the alternating lines because trapped fluid will expand from heating and burst the lines. Here again, the selector valves can be designed to allow the fluid in the alternating lines to have free flow back to return. Look at the top illustration in figure 4-7. Notice that it says FULL-TRAIL. When a valve is in full trail position, it will allow the fluid in the alternating lines to have free flow back to return. Notice that the control spool has three lands (flat portions of the spool that cover up the passageways). Notice that the center land is covering the pressure passageway. With this pressure passageway blocked, the valve is in neutral



FULL-TRAIL VALVE
NON-ENERGIZED



HALF-TRAIL VALVE
NON-ENERGIZED



NON-TRAIL VALVE
NON-ENERGIZED

42-1906

and is called a closed center valve. The two outer lands do not cover the return passageways. As you can see, fluid from the alternating lines can flow through the alternating ports past the control spool lands and through the passageway to the return.

The middle illustration of figure 4-7 shows a selector valve in the HALF-TRAIL position. Notice that the center land is covering the pressure passageway. The right land in this case is covering the right return passageway, thus blocking the return flow from the right return port from flowing back to the return. The left land, as you can see, is thinner than the right land. By being thinner than the right land, it cannot cover the left return passageway completely. This then allows fluid from the left alternating line to flow back to the return. Half trail, then, indicates that half of the valve allows fluid to be trapped in the alternating lines while the other half doesn't.

Another position is called NON-TRAIL; it is illustrated at the bottom of figure 4-7. Here again notice that the center land is covering the pressure passageway. The outer two lands are covering the return passageways. Thus, you can see that any fluid that is in the alternating lines cannot flow back to the return when the control spool is made like this.

Exercises (434):

1. When a selector valve is said to be non-trail, what does this indicate?
2. Why would you want to have a valve that is designed as a full-trail valve?
3. What does half trail mean?
4. Are both alternating ports connected to return in the half-trail position?
5. If all three lands of the control spool cover up the passageways in the valve, what position is this called?
6. When we say full trail, half trail, or non-trail, are we talking about when the valve is energized or nonenergized? Explain.

Figure 4-7. Full-trail, half-trail, and non-trail positions.

435. Specify the operation of a solenoid-operated selector valve with manual control.

Solenoid-Operated Selector Valve With Manual Override. As previously explained, there are selector valves that are manually operated, and there are others that are electrically operated. The valve we will talk about next has both features incorporated into it, solenoids for normal operation and a manual operation for emergency use. The valve, shown in figure 4-8, is in the neutral position with neither solenoid energized, and the alternating lines (gear up and gear down) are connected to the return line. Notice that the pressure can flow past the control spool to the pilot spool. Springs on both sides of the pilot spool and control spool keep the valve in the neutral position. If the left-hand solenoid is energized, it causes the pilot spool to be drawn toward the energized solenoid. This shifts the pilot spool to the left and lets system pressure enter the right side of the control spool. As the control spool is shifted, it blocks off the return line and opens up the pressure line to go out the gear down line. Any fluid in the gear up alternating line will be routed through the valve to the return line. As long as the left solenoid is energized, the valve will stay in this position. When electrical power is dropped, the spings position the selector valve back

to neutral. If electrical power is lost, you can position this valve by pushing the manual override buttons on each side of the solenoids. When the right manual override is pushed in, it positions the pilot spool the same as if the left solenoid were energized. The button will have to be held in until the operation required has been completed. Caution: With this type of manual selection, it is possible to bypass other safety features which are tied into the electrical control circuits.

Exercises (435):

Using figure 4-8, state the position of various components in the selected selector valves.

1. If the left solenoid in figure 4-8 is energized, in which direction will the pilot spool move?
2. If the manual override on the left side is pushed, in which direction will the control spool move?
3. With no solenoid energized, the control spool is in what position?

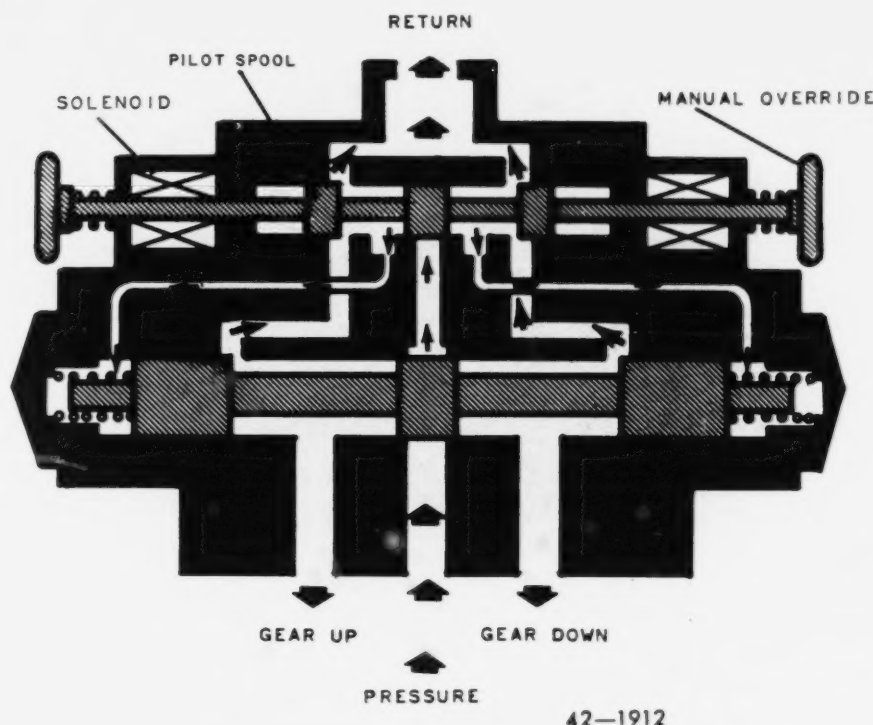


Figure 4-8. Solenoid-operated selector valve with manual override.

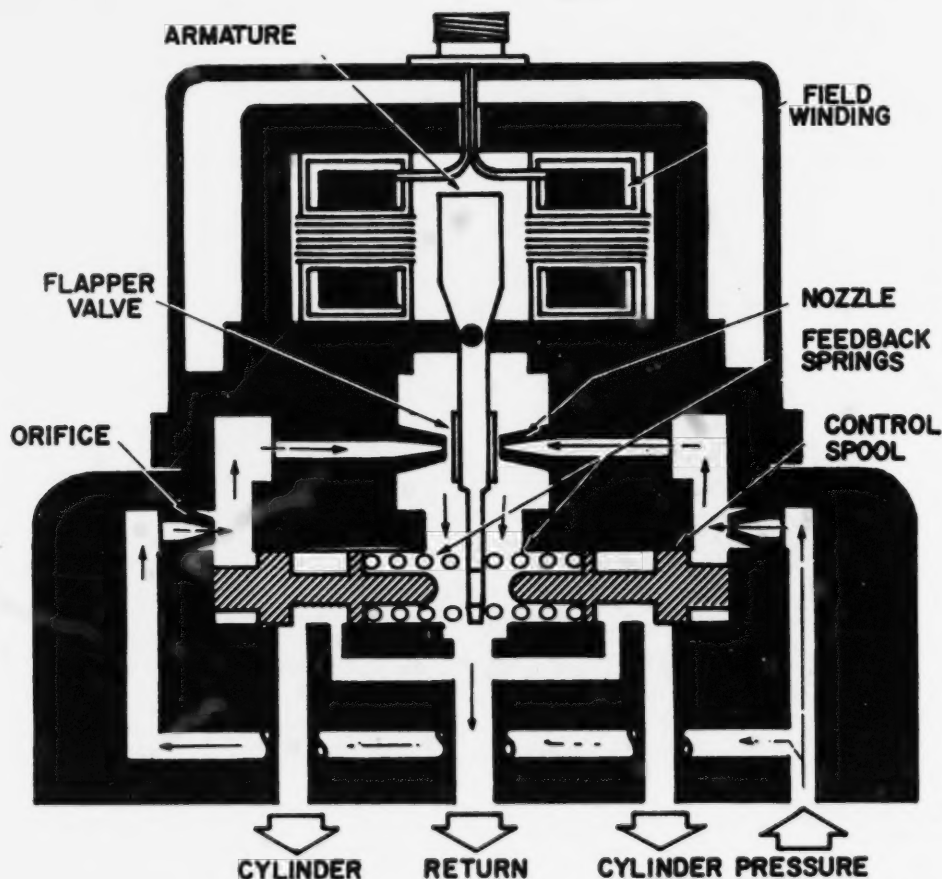
436. State the major difference between a conventional selector valve and a servo valve, and specify the operational features of both the flapper and jet pipe servo flow control valves.

Servo Control Valves. The flow control servo valve is an electrohydraulic valve that will direct fluid flow to a subsystem or component much like a conventional selector valve. The difference between a selector valve and the servo valve lies in the fact that the servo valve will also control the flow of fluid through it as well as directing the flow. To understand how this happens, we'll examine two types of servo control valves—the flapper valve type and the jet pipe type.

Flapper servo valve. Figure 4-9 shows a flapper servo valve, commonly called a flapper valve, in the neutral position. This valve contains two sliding control spools, two feedback springs which are, at the present time holding the flapper valve in neutral, and a torque motor with field windings

(coils) and an armature which is attached to the flapper valve. Two orifices are located in the pressure line to each flow nozzle. When the valve is in the position shown in figure 4-9, fluid continuously flows from the pressure port through the two flow nozzles, past the flapper valve, and out the return. Now refer to figure 4-10 as we talk about its operation. When the servo valve receives an electrical signal, current through a coil (the left coil in this instance) will cause the torque motor armature to pivot. As the armature pivots, it moves the flapper valve, which compresses the right feedback spring against the right control spool. At the time that this takes place, the flapper valve is positioned over the hole in the right nozzle.

Hydraulic pressure will now build up behind the right control spool. The pressure buildup forces the right control spool to move to the left against the spring tension, opening the pressure port to the right cylinder port. As long as fluid flowing out the cylinder port and through the orifice is equal, the



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Figure 4-9. Flapper servo valve (neutral position).

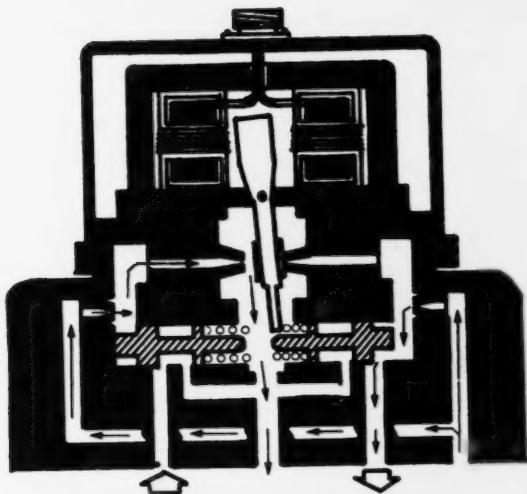
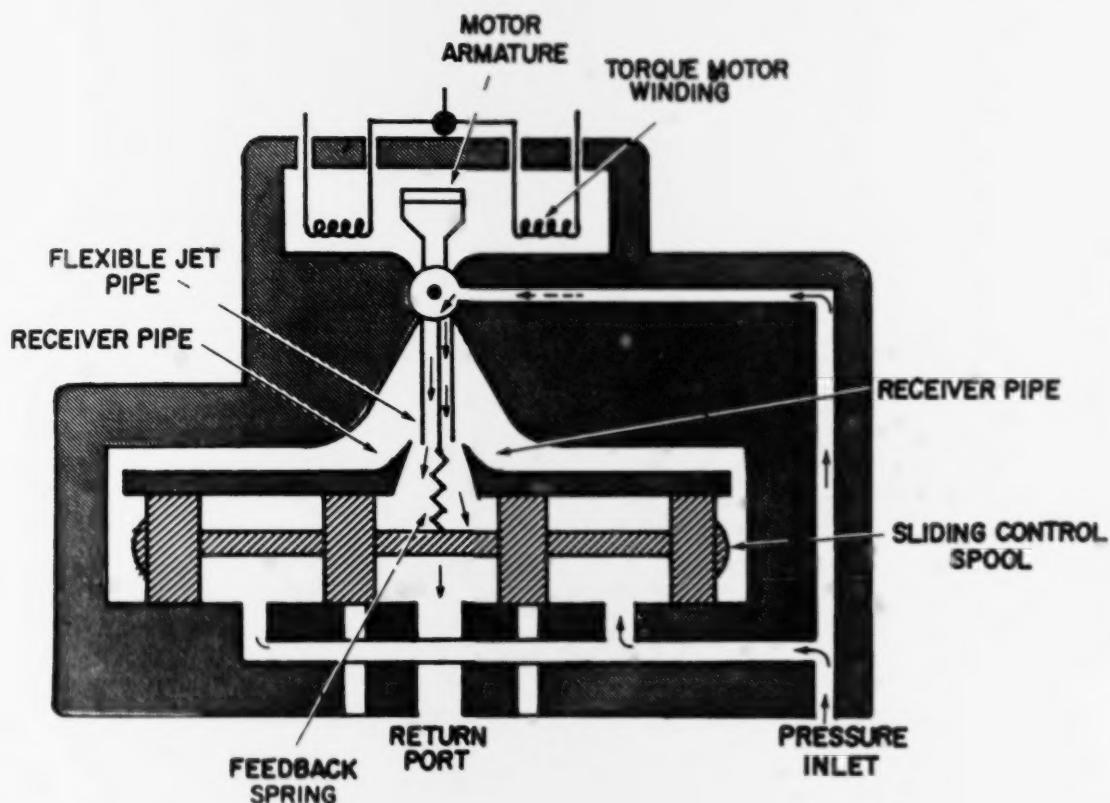


Figure 4-10. Flapper servo valve (energized).

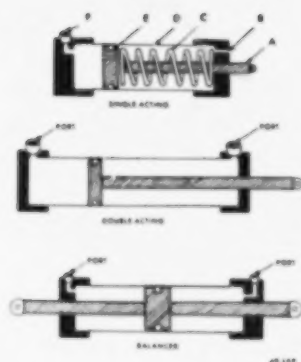
valve continues to operate this way. Whenever the pressure on the cylinder builds up, it provides a back pressure that forces the control spool farther to the left, further compressing the feed back spring. This will force the flapper valve to move off the opening of the nozzle. When this happens, the fluid will now flow through the nozzle and back to the return. This will drop some of the pressure behind the right control spool, which will let the spring force the sliding piston back to the right, closing off the cylinder port. The feedback spring tension, the electrical input, the amount of fluid allowed to flow through the nozzle, and the pressure behind the control spool must all be equal to hold the servo valve in a set position. The servo valve will stay in this set position until another electrical signal is received.

Jet pipe servo valve. The jet pipe servo valve does basically the same thing as the previous servo valve explained, the only difference being in the way it is done. The valve (see fig. 4-11) contains a sliding control spool, feedback spring (attached between jet pipe and control spool), torque motor, flexible jet pipe, and two receiver pipes. A small



42-1908

Figure 4-11. Jet pipe servo valve.



- | | |
|---------------|-----------------------|
| A. Piston rod | D. Cylinder barrel |
| B. Vent | E. Piston (with seal) |
| C. Spring | F. Pressure port |

Figure 4-12. Types of actuating cylinders.

amount of hydraulic fluid flows continuously through the servo valve, from the pressure port, through the jet pipe, and then to return. When the control valve receives a signal, the torque motor will change the position of the motor armature. As an example, let's say that the armature is positioned to the left. When this happens, the flexible jet pipe is positioned over the right receiver pipe. The receiver pipe is like a funnel. Hydraulic fluid now passes from the flexible jet pipe through the right receiver pipe and then to the right side of the control spool. The buildup of hydraulic pressure causes the control spool to shift to the left. As the control spool shifts, it allows fluid to flow to the right cylinder port. A counteracting force, created by the feedback spring connected between the jet pipe and the control spool, becomes equal to the force developed by the torque motor and repositions the jet pipe away from the receiver pipe. This equalizes the pressure applied to the ends of the control spool, holding it at a new position until the servo valve again receives a signal.

Exercises (436):

1. What is the major difference between a selector valve and a servo valve?
2. If the solenoid on the right side of the flapper servo valve is energized, in which cylinder port will the fluid flow?
3. If the control spool on the right side of the flapper servo valve is covering the cylinder port, what does this indicate?

4. Which components in the jet pipe servo valve move?

5. If fluid from the jet pipe is directed into the left receiver pipe, what will happen?

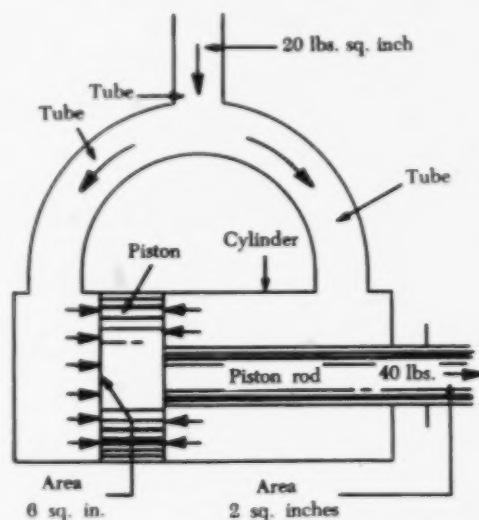
4-2. Actuators

The purpose of a hydraulic actuator is to transform fluid pressure into mechanical force of action. This force can be exerted in a straight line or in a rotary direction. The direction depends on the type of actuators used. An actuating cylinder is generally used for straight line action, whereas hydraulic motors are used for rotary action.

In recent years, the standard actuating cylinders have been changed into more complex units. Snubbing and locking mechanisms have been built into the cylinder itself. Others have valves or switches which are used for the electrical operation of such systems as the autopilot or the automatic flight control.

437. Given certain functions or characteristics, specify the actuator that would best meet the needs of the situation.

Actuating Cylinders. As stated earlier, actuating cylinders are used to produce a linear motion (straight in and straight out). The actuating cylinder, figure 4-13, consists essentially of a



42-1904

Figure 4-13. Difference in areas of an actuating cylinder.

cylinder barrel (D), a piston (E), one or two piston rods (A), ports, and the necessary seals. Actuating cylinders are usually double-acting; that is, fluid under pressure can be applied to either side of the piston so as to cause movement in either direction. Single-acting actuators with a spring return are used in some instances to actuate brakes and to charge machine guns. Balanced type actuators are used to obtain the same amount of force in either direction. Let's cover each one separately.

Single-acting actuating cylinder. The top drawing in figure 4-12 shows the single-port, single-acting actuating cylinder. Fluid under pressure enters the pressure port (F) and moves the piston (E) toward the opposite end of the cylinder. In doing so, it compresses the spring (C). When the pressure is released, the spring returns the piston to its original position. Note that the chamber behind the piston is vented (B) to permit free movement of air in and out.

Double-acting unbalanced actuating cylinder. The second drawing in figure 4-12 shows a two-port actuating cylinder. These actuating cylinders are commonly used with landing gear, wing flap, speed brake, and cargo door systems. Fluid under pressure entering the right-hand port forces the piston to the opposite end of the cylinder. It thereby moves the mechanism attached to the rod. At the same time, the fluid ahead of the piston is forced out of the cylinder. It is returned through the selector valve back to the reservoir. If fluid under pressure is sent into the left-hand port, the direction of the piston is reversed. Fluid ahead of the piston is again forced out of the cylinder and returned to the reservoir. With this type of actuating cylinder, a mechanism can be moved in either direction. It is done by changing the direction of flow of the fluid as controlled by the selector valve.

Sometimes a mechanism requires more force to move it in one direction than the other. The double-acting unbalanced actuator will provide these unlike forces. Assume that the double-acting cylinder, shown in the center of figure 4-12, is a landing gear actuating cylinder. When the piston moves to the right and the piston rod moves out of the cylinder, the gear is raised. When the piston moves to the left, the gear is lowered.

The reason for this construction is that a greater force is required to raise the gear than to lower it.

The higher force is obtained by having the fluid act on the full area of the piston. Less force is obtained by the fluid's action on the smaller area of the rod side of the piston.

To fully understand this action of the piston, consider the situation shown in figure 4-13. Here, a single piston in a cylinder has a piston rod which extends out of the cylinder. Fluid under pressure is admitted equally through tubes to both ends of the

cylinder. The opposed faces of the piston behave like two pistons acting against each other. The area of one face is the full area of the cylinder—in this instance, 6 square inches. The area of the other face (4 square inches) is the area of the cylinder minus the area of the piston rod (2 square inches). The pressure applied to both faces is the same, 20 psi. The formulas in Volume 2 regarding force, area, and pressure apply here. Applying these rules, you can see that the force pushing the piston to the right is its area (6 square inches) times the pressure (20 psi), or 120 pounds. Similarly, the force pushing it to the left is its area (4 square inches) times the pressure (20 psi), or 80 pounds. Therefore, there is a net unbalanced force of 40 pounds, which forces the piston to the right.

Double-acting balanced actuating cylinder. This cylinder, shown at the bottom of figure 4-12, is similar to the double-acting type. But, in this case, the piston rod extends through the piston and out through both ends of the cylinder. One or both of these piston rods may be attached to a mechanism. In either case, the rods are used to provide equal areas on each side of the piston. Therefore, by the formula, with equal pressure we will get an equal force applied on each piston face. Also, the same quantity of fluid will move the piston the same distance either way. Flight control and nosewheel steering systems often use this type of actuating cylinder.

Exercises (437):

Below is a list of actuator functions and characteristics. Place the letter of the appropriate actuator in the blank provided alongside the function or characteristic.

- | | |
|------------------------------|--|
| a. Single-acting. | _____ 1. Used to actuate brakes. |
| b. Double-acting unbalanced. | _____ 2. Used when more force is required to move an object one way than the other. |
| c. Double-acting balanced. | _____ 3. Used on landing gear and flaps. |
| | _____ 4. Offers equal force in either direction. |
| | _____ 5. Used on nosewheel steering and flight controls. |
| | _____ 6. Has piston rod that extends through both ends of the cylinder. |
| | _____ 7. Used in systems where the same quantity of fluid will move the piston the same distance either way. |

438. Specify the operational and constructional features of tandem actuators.

Tandem Actuators. Actuators are used in conjunction with power-operated flight control systems. Their function is to assist the pilot in handling the aircraft, just as power steering helps a driver with an automobile. In a power-operated flight control system, all the force necessary for deflecting the control surface is supplied by hydraulic pressure. Each moveable surface is operated by a hydraulic actuator incorporated in the control linkage. Some aircraft manufacturers refer to these units as power control cylinders. Typical flight control surface actuators are shown in figure 4-14. Notice that they are balanced and have slide control valves. Now look at the top illustration in figure 4-14. This particular actuator uses fluid from only one system. The slide control valve is blocking the pressure going into the actuator and the return lines. This blockage keeps the fluid inside the actuator from flowing through the return system. When the slide control valve has been moved to the right, it allows fluid to flow from the pressure line into the left side of the actuator cylinder. Fluid from the opposite side is forced out past the control spool back through the return. If you wanted the actuator to move in the other direction, you would have to position the control valve to the left. Now notice the tandem actuator shown in the bottom illustration of figure 4-14. Tandem means one behind the other. In this case you can see that it has a longer slide control valve, two pistons, and two hydraulic systems. Half of the slide control valve is connected to one hydraulic system, and the other half of the control valve is connected to another hydraulic system. This is a common primary arrangement, particularly for operation of the primary flight control systems on

high performance aircraft. Since the control valve operates each time the control lever is positioned, the failure of either hydraulic system will not render the actuator inoperative. Though failure of one system reduces the output force by one half, the remaining force is sufficient to permit the handling of the aircraft at certain airspeeds (always well above that required for a safe landing).

Exercises (438):

1. How many pistons are found in a tandem actuator?
2. Why is it necessary to block off the return ports when the slide control valve is in neutral?
3. If a tandem type actuator is used on the primary flight controls, will it be able to handle the aircraft if one hydraulic system fails?

439. State the purpose of an internal snubber actuator, and specify its operational features during retraction and extension.

Internal Snubber Actuator. The purpose of this type of actuator is to reduce damage to mechanisms by preventing the actuator from slamming into its end of travel with great force. Travel is slowed down when the piston nears either end of the

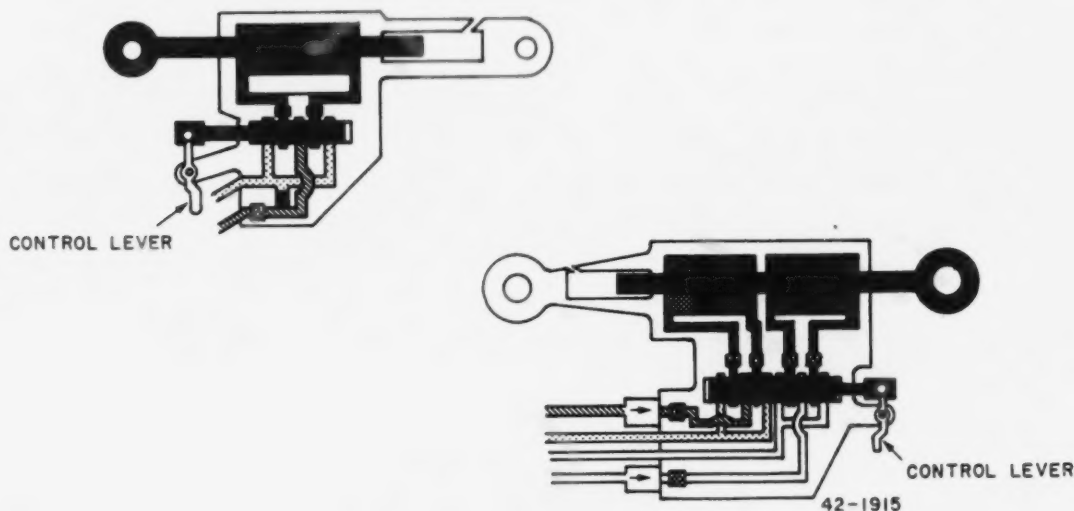


Figure 4-14. Single and tandem actuating cylinders.

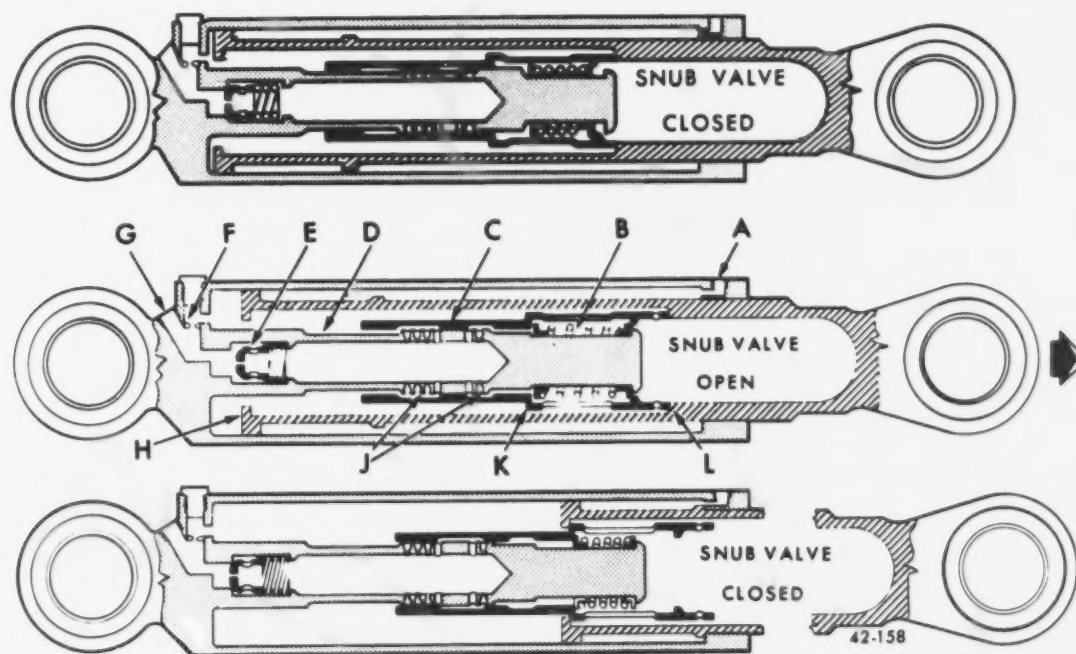
cylinder. This eliminates the need for external cushioning devices. Figure 4-15 is a typical example of an actuator with an internal snub valve assembly. The snub valve (D) is a chamber within the left chamber of the cylinder (fig. 4-15). Fluid can enter and leave the snub valve chamber through snub valve passageways (J) and the restrictor check valve (E). Most of the fluid that moves the piston either way must pass through this chamber. During the middle portion of the piston's travel, this fluid flow is quite unrestricted. That means that the piston, rod, and attached mechanism can move rapidly. But, as the piston reaches either end of its travel, the openings into the snub valve (D) chamber become restricted. This means the flow of actuating fluid through the chamber also becomes restricted. This slows down the speed of the piston at the end of its travel in both extend and retract modes.

The sleeve (C) and the spring (B) are important parts of the snub valve. Notice, in each "Snub Valve Closed" view in figure 4-15, the sleeve (C) blocks most of the passageways (J). In the "Snub

Valve Open" view, the passageways are unblocked. When the passageways are open, the piston can move rapidly. When they are closed, the piston moves slowly.

The top view of figure 4-15 shows the actuator fully retracted. The shoulder of snub spring operator (L) has contacted the sleeve (C) and moved it to the left. In doing so, it compressed the snub valve spring (B). During the compression of the spring, the sleeve (C) moved far enough to block the passageways (J). This slowed the travel of the piston during the last part of retraction. Since the extend port (G) is connected to the return line during retraction, the restrictor check valve (E) is closed.

The middle view shows the actuator beginning to extend. Fluid pressure enters the extend port (G). Looking at the top view again, a small amount of fluid will pass through the orifice (F). Other fluid will push back the check valve (E), and a small amount will pass out the snub valve chamber (D) through the passageways (J). The combined force of the fluid going through the orifice (F) and the



- A. Retract port
- B. Snub valve spring
- C. Sleeve
- D. Snub valve
- E. Restrictor check valve
- F. Orifice

- G. Extend port
- H. Snub spring operator
- J. Snub valve passageways
- K. Snub spring operator shoulder
- L. Snub spring operator

Figure 4-15. Internal snubber actuating cylinder.

passageways (J) will start extending the piston slowly. When the piston has reached the point shown in the middle view, the passageways (J) are wide open. Now there is full flow from the extend port (G), through the check valve (E), through the passageways (J), and to the piston face. The piston now can move at full speed.

When the piston is almost fully extended, another shoulder of the snub spring operator (H) contacts the shoulder (K) on the sleeve (C). This is shown on the bottom view of figure 4-15. As the piston extends the last distance, it pushes the sleeve to the right, thereby blocking the passageways (J). This immediately reduces the force acting on the piston because the actuating fluid is now restricted to the orifice (F). Because of the reduced fluid input, the piston must slow down during this last fraction of its travel. The bottom view now shows the actuator at rest, fully extended. Notice that the final travel compressed the spring (B) and closed the check valve (E).

Now let's follow the operation of the actuator during retraction. Fluid pressure enters through the retract port (A). It exerts force on the opposite face of the piston and pushes the piston to the left. As the piston moves, the fluid in front of it must pass out through the extend port (G) to the return line. With the passageways (J) almost completely closed, the fluid must pass through the orifice (F) to escape. This orifice restricts the first flow of fluid and the piston travel to slow motion. However, as soon as the sleeve (C) moves left far enough, propelled by the spring (B), the passageways are opened. Now the major fluid flow can pass out through the chamber of the snub valve (D), through the orifice in the check valve, to the extend port. As a result, the piston speed increases.

When the piston reaches the point shown in the middle view, the snub spring operator (L) again contacts the sleeve. The sleeve moves left and starts to block the passageways. This slows the piston, which ends up in the position shown in the top view—retracted. During extension, the actuator reduces speed by restricting input fluid. During retraction, speed is reduced by restriction of outflow fluid. Notice the small openings in the extreme left end of the sleeve (C); they connect the right end and the left end of the extend fluid chamber. The actuator shown in this figure produces more force when it extends than when it retracts.

Exercises (439);

1. What is the purpose of the internal snubber actuator?

2. Which component in the actuator restricts fluid flow when the actuator is almost retracted?
3. When the snub valve passageways (J) on the snub valve are unrestricted, what position is the actuator in?
4. When the actuator is fully retracted, in what position is the restrictor check valve?
5. How are the snub valve passageways blocked when the actuator is retracted?

440. Specify the function and operational characteristics of internal locking type actuators.

Internal Locking Actuators. There are many cases where a hydraulically operated unit must be locked in position to prevent it from moving out of position. Such units may be the wing flaps, landing gear, speed brakes etc. Because of the limited space on some aircraft, locking devices may take up too much room; therefore, the lock must be built right inside the actuating cylinders. In this section we will cover two such locks—the ball lock, and the toggle lock.

Double-acting ball lock actuator. This actuator is shown in figure 4-16. This is a simple double-acting unbalanced cylinder, except that a locking mechanism at each end of the cylinder retains the piston in either the extended or the retracted position.

When the hydraulic pressure is ported into the right side of the cylinder, it causes the piston and rod to retract. As the piston nears the end of its travel, a series of balls, set around the piston, contact and depress a locking plunger against the locking plunger spring. Further movement of the piston will cause the locking plunger to force the balls out against the detent. The actuator is now locked in the retracted position. In order to unlock this actuator, you must apply pressure to the left hand port. As pressure tries to extend the actuator, it forces the locking plunger to the left, compressing the spring. As the locking plunger moves, it allows the locking balls to move out of the detent, freeing the piston and allowing the piston to extend. As it nears the fully extended position, the same sort of action which locked it into the retracted position takes place to lock it into the extended position.

Toggle-lock actuator. Figure 4-17 shows a typical actuating cylinder (B) with an internal lock. This

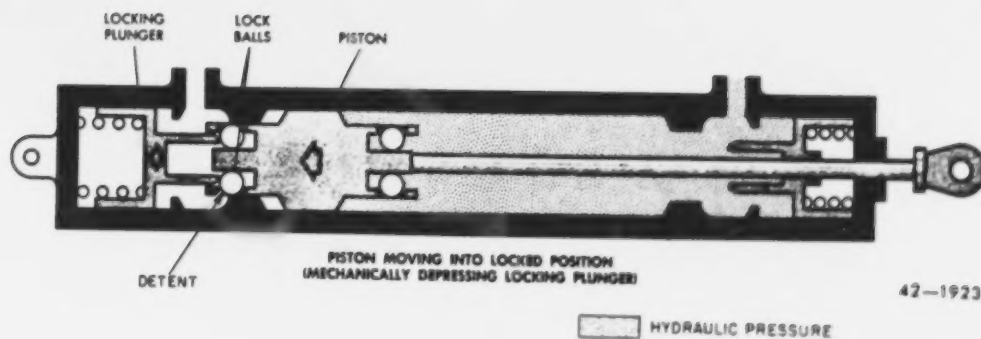


Figure 4-16. Double-acting ball lock actuator.

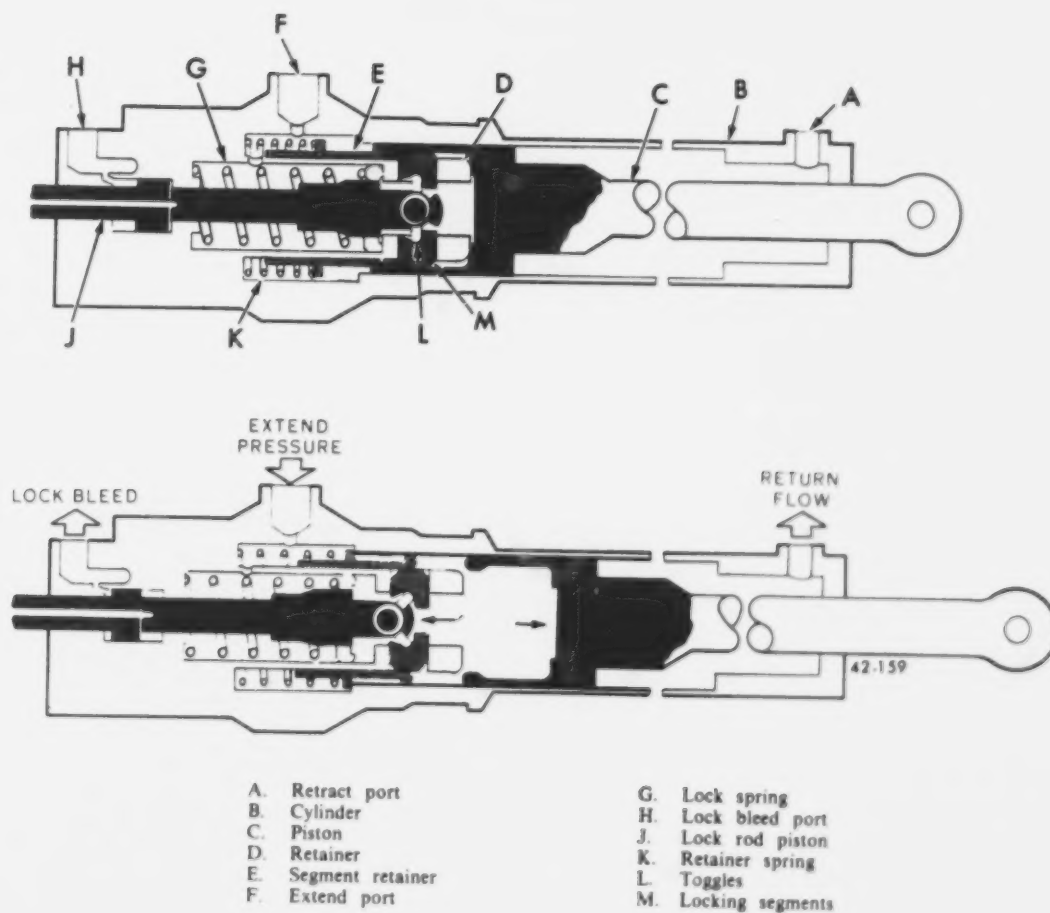


Figure 4-17. Internal lock actuating cylinder.

actuator will lock itself in the retracted position. The weight of any mechanism attached to the rod cannot extend the rod. To unlock it hydraulically, fluid pressure must be applied to the extend port. A cable can be attached to the hollow stem of the lock and lock rod piston shaft (J). This way the actuator can be unlocked manually, which might become necessary in an emergency or during ground operation, by pulling on the cable. Now let's talk about how the piston locks.

When fluid enters the retract pressure port (A), it pushes the piston (C) to the left. As it approaches the lock, the lips of the hollow piston head enter the space between the retainer (D) and the cylinder wall. Compare the upper and lower views of figure 4-17. As the lips slide in, they contact the segment retainer (E) and push it back, compressing the retainer spring (K). (See fig. 4-17, upper view). When the lips pass beyond the locking segments (M), the segments will spring up behind the lips. When the segments move outward, they make more space for the toggles (L). The toggles can now take the vertical position, as shown in the upper view of the figure. When the toggles move to the expanded position, the lock rod piston (J) can move to the right. The lock spring (G) pushes the lock rod piston to the right. There it locks the toggles that in turn lock the segments that lock the piston. This action prevents the piston from being pulled out.

To unlock the piston and extend it, fluid pressure is sent into extend pressure port (F). The fluid flows into all chambers between the head of the piston (C) and the head of the lock rod piston (J). Because it is locked, it cannot move the piston (C) to the right. It can, however, push the lock rod piston (J) to the left while compressing the lock spring (G). When the lock rod piston (J) moves left, it pulls the toggles (L) partly out from between the locking segments (M) and unlocks them. Now the lips of the piston (C), which are pulling to the right, can depress the locking segments and escape. As the lips slide over the segments to the left, the retainer spring (K) pushes the segment retainer (E) to the right. The retainer slides over the locking segments and holds them ready to accept the lips again when they return.

The lock bleed port (H) is connected to return in order to drain any fluid which might collect behind the lock rod piston (J). This prevents a fluid lock at this point. Such an actuator can be used in many hydraulically operated subsystems.

Exercises (440):

1. Where would internal locking actuators be used?

2. What function does an internal locking actuator serve?

Using figure 4-16, answer the following questions.

3. What forces the lock balls against the detent?
4. What must happen before the lock balls are allowed to move out of the detent to unlock the actuator?

Using figure 4-17, answer the following questions.

5. What happens to the locking segments as the actuator piston retracts and supplies a pressure to the segment retainer.
6. What happens to the lock rod piston once the toggles are allowed to extend?
7. What items will lock the locking segments in position?
8. What piston is moved by hydraulic pressure to unlock the actuator?

441. Differentiate between a nonautomatic and an automatic position control, and specify constructional features of the three types of followup mechanisms.

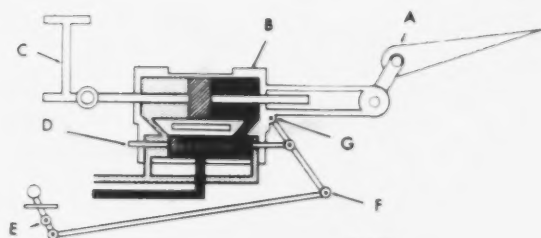
Nonautomatic Position Control Systems. Nonautomatic actuating systems are used when full travel of the actuator is required for each operation of the unit. Landing gear and bomb-bay door systems are examples of this.

This type of system is manually controlled by the operator. When the selector valve is moved to an operating position, fluid pressure (main pressure line) is sent to the actuating cylinder. The piston moves to its extreme limit of travel. To stop the piston before the end of its travel, the operator must return the selector valve to neutral. Most valves have a neutral position. The simplest

nonautomatic control system contains a selector valve and an actuating cylinder.

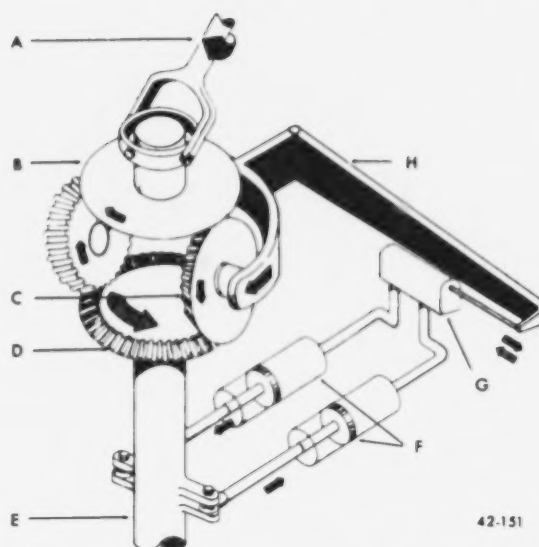
Automatic Position Control Systems. These systems provide automatic control of actuating mechanisms such as nosewheel steering, flight control systems, and some wing flap systems. These systems have followup systems which limit the movement to a desired amount automatically. For example, when the manual control is moved a certain distance, the selector valve is positioned. Hydraulic pressure is directed to the actuating cylinder, and it begins to move. The actuated mechanism will move the amount called for on the manual control. At that point, the followup system will return the valve to neutral. This stops further movement and is done without any action on the part of the operator. As long as the manual control is being moved, it stays ahead of the followup action. This action keeps the selector valve in an operating (open) position. The followup mechanisms used on these systems may be either mechanical, differential, or electrical.

Mechanical followup system. The mechanical followup system operates through a system of cables and pulleys or rigid linkage. Figure 4-18 represents a hydraulic flap system which uses a single mechanical linkage and a series of pivot points. This unit includes both a selector valve and an actuating cylinder. It is attached to a stationary part of the airframe (C). The control handle is connected to the selector valve by connecting rods. The control handle has a pivot point (E). These connecting rods are anchored at one end to another pivot point (G). When the top of the control handle is moved to the left, the connector rod moves to the right. This pulls the selector valve (D) piston to the right. The selector valve sends fluid pressure (represented by the solid line) to the right side of the actuating cylinder (B). The pressure tries to move the piston to the left. The piston itself cannot move since it is directly attached to the airframe.



- | | |
|-----------------------|-------------------------------|
| A. Control surface | E. Control handle pivot point |
| B. Actuating cylinder | F. Pivot point |
| C. Airframe structure | G. Pivot point |
| D. Selector valve | |

Figure 4-18. Mechanical followup system.



- | | |
|-----------------------------|-----------------------|
| A. Control handle | E. Nose gear strut |
| B. Manual control gear | F. Actuating cylinder |
| C. Pinion gears | G. Selector valve |
| D. Actuating mechanism gear | H. Operating arm |

Figure 4-19. Differential followup system.

Therefore, hydraulic pressure moves the entire assembly (actuating cylinder and selector valve) to the right, and this raises the flaps (A). When the movement of the control handle is stopped, one of the pivot points (F) becomes stationary. However, another pivot point (G) moves with the total assembly. The assembly moves to the right, and the selector valve piston (D) stands still. This continues until both actuator ports are closed. The selector valve is now in neutral and cuts off pressure to the right side of the actuating unit. The flap movement is stopped.

The control handle may be placed in any position within its range of travel. Any movement of this control handle positions the selector valve and starts the actuating unit moving. The unit's movement over the piston is the followup system. When it moves the proportional amount, the selector valve is neutralized.

Differential followup system. The differential followup uses a set of opposed gears. The gears are included in a separate housing from the actuating unit itself. Figure 4-19 shows a typical unit used on a nosewheel steering mechanism, the control handle (A) is attached directly to the manual control gear (B). The four gears in the differential are all meshed. The control gear meshes with two pinion gears (C).

As the manual control handle (A) is rotated clockwise, the pinion gears move around the actuating mechanism gear (D). At this point in the

operation of the differential unit, the actuating gear (D) remains stationary. The operating arm (H) is attached to the pinion gear cage and connects to a slide selector valve (G). When the pinion gears (C) move, the operating arm (H) moves also. It, in turn, moves the sliding spool of the selector valve (G).

This results in pressure being directed to one of the actuating cylinders (F). The cylinders (F) turn the nose gear strut (E) to steer the airplane. However, when the nose gear strut (E) turns, the actuating gear (D) turns with it. This causes the pinion gears to walk around the control gear (B), which is held stationary by input force on the control handle (A). This action moves the operating arm (H) in the opposite direction, neutralizing the selector valve action. This cuts off fluid flow to the actuating cylinder.

Continual movement can be achieved by keeping the manual control moving ahead of the followup. As soon as the manual control is stopped, the followup motion will "catch up," neutralizing the selector valve. This stops the steering operation.

Electrical followup. The electrical followup system works on a servo loop principle. This

consists of four basic items: an input transducer (potentiometer), an amplifier (computer), a servodevice (usually a servovalve and actuator), and the followup transducer. (See fig. 4-20). Whenever the input transducer is positioned, it sends a signal to the amplifier. If the signal is different from the followup transducer's signal, then it amplifies the input signal and sends it to the servovalve. The servovalve then sends fluid to the actuator. As the actuator moves, it positions the followup transducer, which sends another signal to the amplifier. If the input and followup transducers send the same signal to the amplifier, the amplifier will cancel the two out, and the servovalve will be held in neutral position.

Exercises (441):

1. What is the difference between an automatic and nonautomatic position control system?

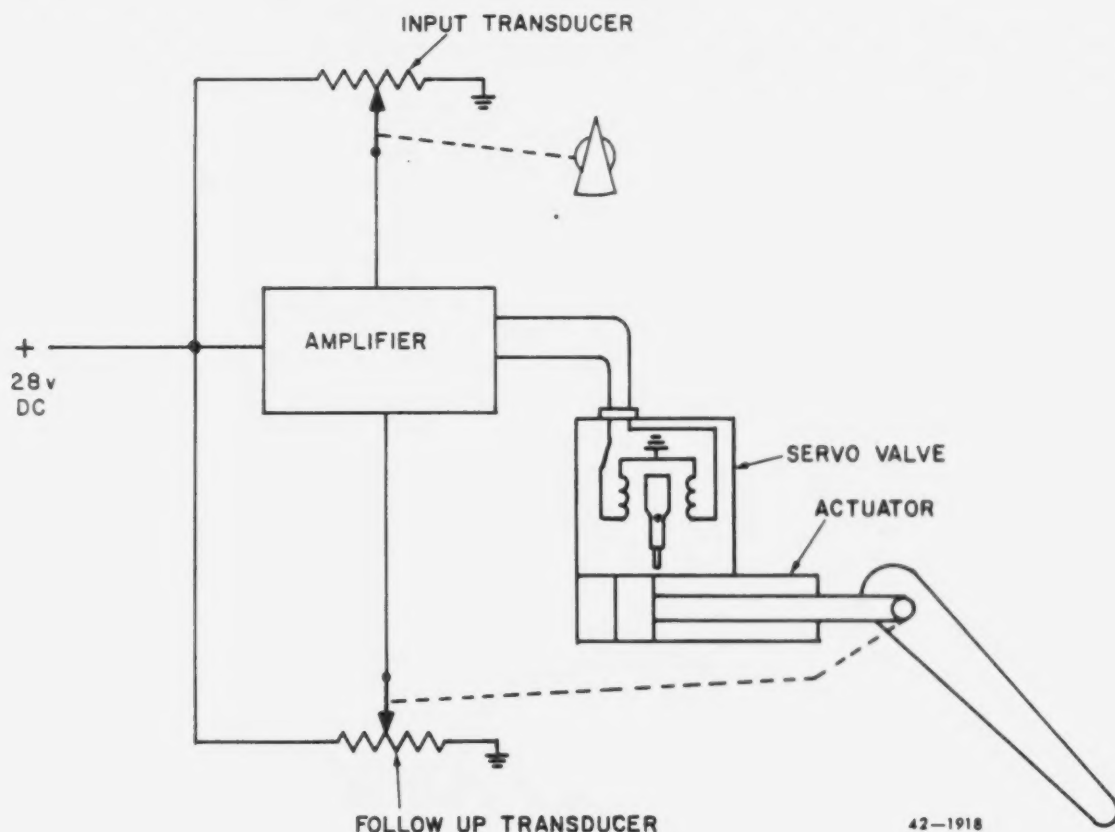


Figure 4-20. Electrical followup system.

2. Which position control system (automatic, or nonautomatic) is used on systems that require full travel of the actuator?
3. Which position control system has a followup system which limits the movement desired?
4. Match the type of followup mechanism in column B to the constructional feature in column A.

Column A
Constructional Features

Column B
Followup Mechanism

- | | |
|---|----------------------------|
| — a. Uses a set of gears. | (1) Mechanical followup. |
| — b. Uses cables and pulleys. | (2) Differential followup. |
| — c. Works on a servoloop principle. | (3) Electrical followup. |
| — d. The action of an operating arm hooked to a pinion gear neutralizes selector valve operation. | |
| — e. A followup potentiometer (transducer) hooked to the control surface will send a signal to the amplifier that will hold the servo valve in neutral. | |

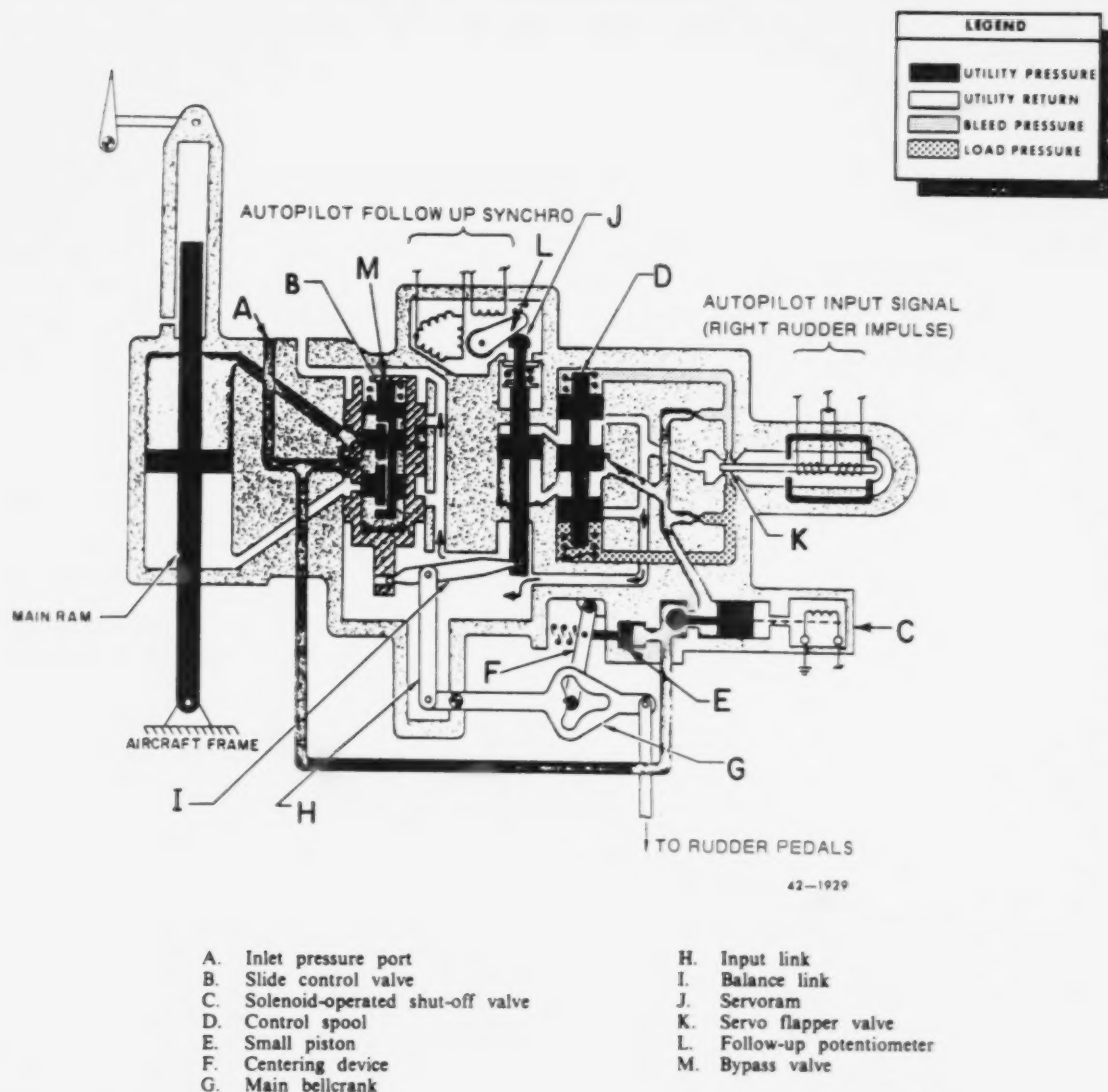


Figure 4-21. Power control cylinder.

442. Specify the operational characteristics of a power control cylinder that incorporates automatic flight control system components.

Power Control Cylinder. This actuator assembly is a combination of many of the other units that have already been discussed in this and previous chapters in this volume. Such items as a balanced actuating cylinder, a slide control valve, a position transmitter (potentiometer), a flow control servovalve, and a solenoid-operated shut-off valve can be found in this unit. If you understood how each of these units operated while they were covered, you should have no problem with the operation of this actuator assembly. This actuator also incorporates an automatic flight control system (AFCS) mode which uses electrical inputs to the flow control servovalve. The AFCS uses an electrical followup system.

This actuator has three ways of being positioned: manual-hydraulically, electro-hydraulically, and manually. We will discuss each of these methods in the following paragraphs.

Manual-hydraulic. This mode doesn't require any electrical power to the actuator. Refer to figure 4-21 as we cover the sequence of operation. Fluid enters the inlet port (A) and flows to the slide control valve (B). Inside the slide control valve is a bypass valve (M) which blocks off passages from each side of the actuator. Notice that the pressure applied has forced the bypass valve up, compressing the spring. We will talk more about this valve later on, when we get into the manual mode. In the meantime, the pressure will also flow to the solenoid-operated shutoff valve (C). This valve is spring-loaded to the closed position. In this position, it prevents fluid pressure from going to the flow control servo valve. Notice that just in front of the solenoid-operated shutoff valve is a small piston (E) which pushes the centering link (F) away from the main bellcrank (G) when pressure is applied to it. This lets the main bellcrank pivot when the push rod is moved. As the main bellcrank is positioned, it forces the pilot input link (H) to move up or down. The pilot input link is attached to the balance link (I), which in turn is connected to the autopilot servoram (J) and slide control valve (B). Because electrical power is not applied, the autopilot is not in use at this time. Therefore, the balance link (I) will position the slide control valve (B) to route fluid to either side of the actuator. Notice that the actuator piston is attached to the aircraft airframe. As a result, the actuator piston does not move; instead, the whole assembly body, valves and all, moves. With this type of setup, the slide control valve will automatically be repositioned to neutral when the desired travel has been achieved. This is the mechanical followup.

Electro-hydraulic. In order for this system to work in this mode, electrical power must be applied

to the automatic flight control system. When the AFCS is turned on, it energizes the solenoid-operated shutoff valve (C) to the OPEN position. (See fig. 4-21.) This allows fluid to flow from the pressure port through the solenoid-operated shut-off valve to the flow control servovalve. If a signal is sent to the flow control servovalve, it positions the flapper valve (K) to restrict fluid in one part of the system. This routes fluid to the control spool (D) of the flow control servovalve. The control spool (D) will send fluid to either side of the autopilot servoram (J). Notice that the bottom part of the servoram (J) is connected to the balance link (I) and that the other end is used to position the followup potentiometer (L). As the servoram (J) moves up or down, it positions the slide control valve (B), which moves the main actuator up or down. As the servoram (J) moves, it also repositions the followup potentiometer (L), which sends a signal to reposition the flow control servovalve. This is the electrical followup.

Manual. In the event of loss of hydraulic pressure, this particular actuator assembly (fig. 4-21) is designed to let the pilot manually move the flight control surfaces. Of course, without hydraulic pressure the pilot has to apply more effort to move the controls. This can be done because, when hydraulic pressure is not present, the main bellcrank (G) is locked to the body of the actuator by a spring-loaded centering device (F). Also the bypass valve (M) inside the slide control valve (B) is forced down by the spring, thus allowing fluid to flow freely from one side of the main actuator to the other. Now, when the pilot moves the push rod, the main bellcrank cannot pivot as it could when hydraulic pressure was available. Since the main bellcrank cannot pivot, the whole actuator assembly must be moved. Remember that the main actuator piston rod is attached to the aircraft structure. So, when the whole actuator assembly moves, fluid from one side of the main actuator must flow from one side of the actuator through the bypass valve (M) to the other side of the actuator. Without this movement of fluid, you would have a fluid lock, and the flight control would not be able to move. As you can see, with the bypass valve installed, the flight controls can move, but it requires more effort on the part of the pilot to move them.

Exercises (442):

1. Name the three ways the power control cylinder can be positioned.
2. When the cylinder is in the manual hydraulic mode of operation, what will move to let hydraulic fluid flow from one side of the main actuator to the other?

3. When the cylinder is in the electro-hydraulic position, is the solenoid-operated valve energized or deenergized?
4. What repositions the followup potentiometer when the power control cylinder is in the electro-hydraulic mode of operation?
5. What is the purpose of the piston (E) attached to centering link (F)?
6. When the power control cylinder is in the manual-hydraulic mode of operation, what unit will position the slide control valve to route fluid to position the actuator?

443. List the differences between a constant volume pump and a hydraulic motor, then specify the operational characteristics of a hydraulic motor.

Hydraulic Motors. Hydraulic motors are used where it is necessary to convert hydraulic pressure into rotary mechanical motion. The type of hydraulic motor most commonly used is similar in general design and construction to the constant volume Vickers pump described earlier in this volume. Although similar, there are a few major differences. In the operation of a pump, when the

drive shaft is rotated, fluid is drawn into one port and forced out the other port under pressure. This procedure is reversed in a motor. Refer to figure 4-22 as we talk about the operation of a hydraulic motor. Notice the valve plate that is used to separate the pressure inlet port from the return outlet port.

When fluid already under pressure is directed into one of the motor ports, it will enter those cylinder bores that are open to the port. This pressure tends to force the pistons to the right, but the pistons cannot move without first rotating the drive shaft. As the pistons move outward again, they line up with the outlet port and force the fluid out through the return port. This cycle is continuous as long as fluid pressure is applied.

To control the speed of a hydraulic motor, you have to control the flow of fluid going to the motor. In most cases this is done with a flow control valve, which we will discuss in another section of this volume. To increase the speed of a motor, increase the flow; to decrease the speed, decrease the flow.

These motors have a case drain but do not have a foot valve, as is found on a constant volume pump. Any leakage past the pistons must flow through the case drain port to return. Hydraulic motors may be operated in either direction of rotation, the rotation being controlled by the direction of fluid flow to the motor ports. You can reverse the direction of rotation instantly, without damaging the motor, by using a selector valve to change the direction of fluid flow into the motor.

Attachment of a torque tube, gear box, or jackscrew to the drive shaft of the motor results in rotary mechanical motion. The gear box shown in

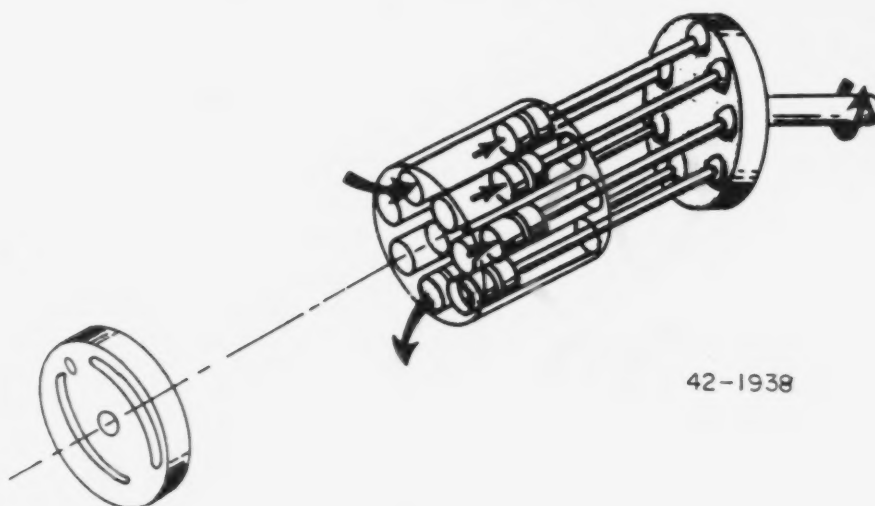


Figure 4-22. Hydraulic motor.

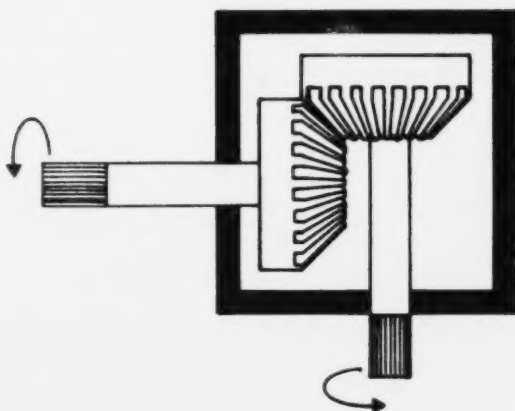


Figure 4-23. Simple gear box.

figure 4-23 will change the angle at which the rotary motion is transmitted. The jackscrew shown in figure 4-24 consists simply of a screw and a nut. The screw turns, and the nut remains stationary. As the screw turns, it actually causes the nut to move back and forth on the screw. This is the principle on which the jackscrew works. If a hydraulic motor were attached to this screw, it would cause the nut to travel the length of the screw.

Exercises (443):

1. List differences between a hydraulic pump and hydraulic motor.
2. What can be used to control the speed of a hydraulic motor?
3. What should be used to change the direction of a hydraulic motor?
4. Explain the principle of the jackscrew.
5. What is the purpose of the gear box shown in figure 4-23?
6. What is the case drain on the motor used for?

444. Specify the operational characteristics of limited rotary actuators.

Limited Rotary Actuators. Many systems require only a limited rotary motion to perform their operation, instead of a continuous rotary motion such as the hydraulic motor has. Some of these systems are windshield wipers, nosewheel steering, and radar antennas. Two types of limited rotary units are primarily used; rack and pinion actuators and vane actuators. Each of these will be explained in the following paragraphs. Later on in this course, we will see how these units can be used to operate a particular system. But, for the time being, we only want you to understand that there are such things and to get a good idea of how they operate.

Rack and pinion actuator. The rack and pinion actuator (fig. 4-25) basically consists of those two parts—the rack (D) and the pinion (C), both of which have gear teeth. Notice that these gear teeth mesh with each other. Attached to the rack are two pistons, one on either side of the rack. Normally, all the components are housed in one unit. The pinion is usually attached to some moveable object so that, when the pinion gear moves, it also moves the object. Let's look at the normal operation of a rack and pinion actuator. When pressure is applied to the left cylinder port (A), it forces the piston to the right. Since the rack is attached to the piston, it also moves, thus forcing the piston on the opposite side to move. Any fluid in the opposite cylinder port will be forced to return. Now, as the rack moves, the pinion gear, which is meshed with the rack gear, will be forced to move (rotate). Any object attached to the pinion gear will also move at the same time.

Vane actuator. One type of vane type actuator is shown in figure 4-26. This unit consists basically of four chambers, two stationary vanes, and two moveable vanes. The moveable vanes are connected to the wingshaft, which extends through the full length of the unit. The wingshaft is attached

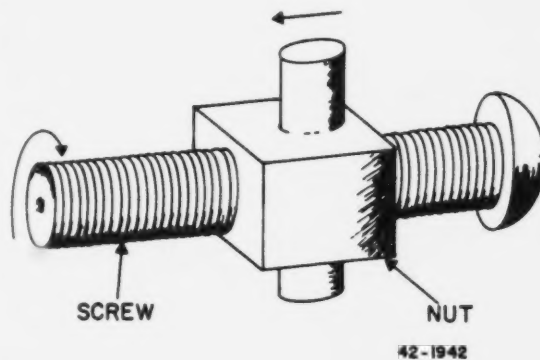
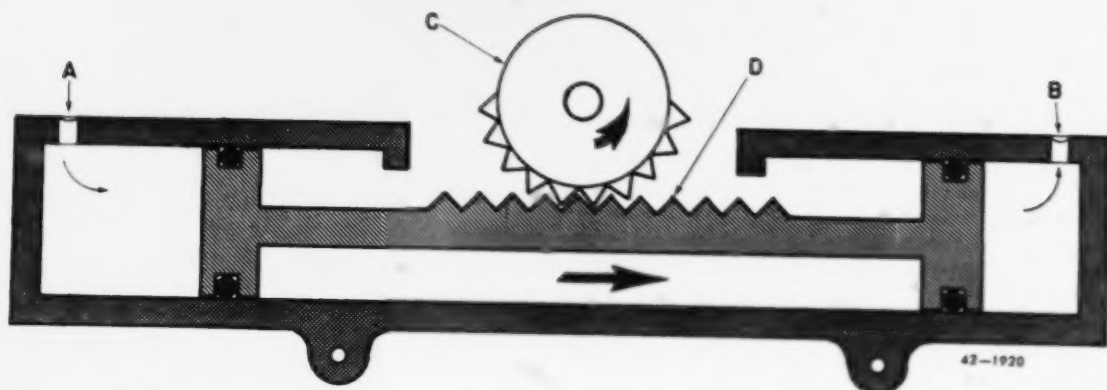


Figure 4-24. Simple jackscrew.



A. Left cylinder port
B. Right cylinder port

C. Pinion
D. Rack

Figure 4-25. Rack and pinion actuator.

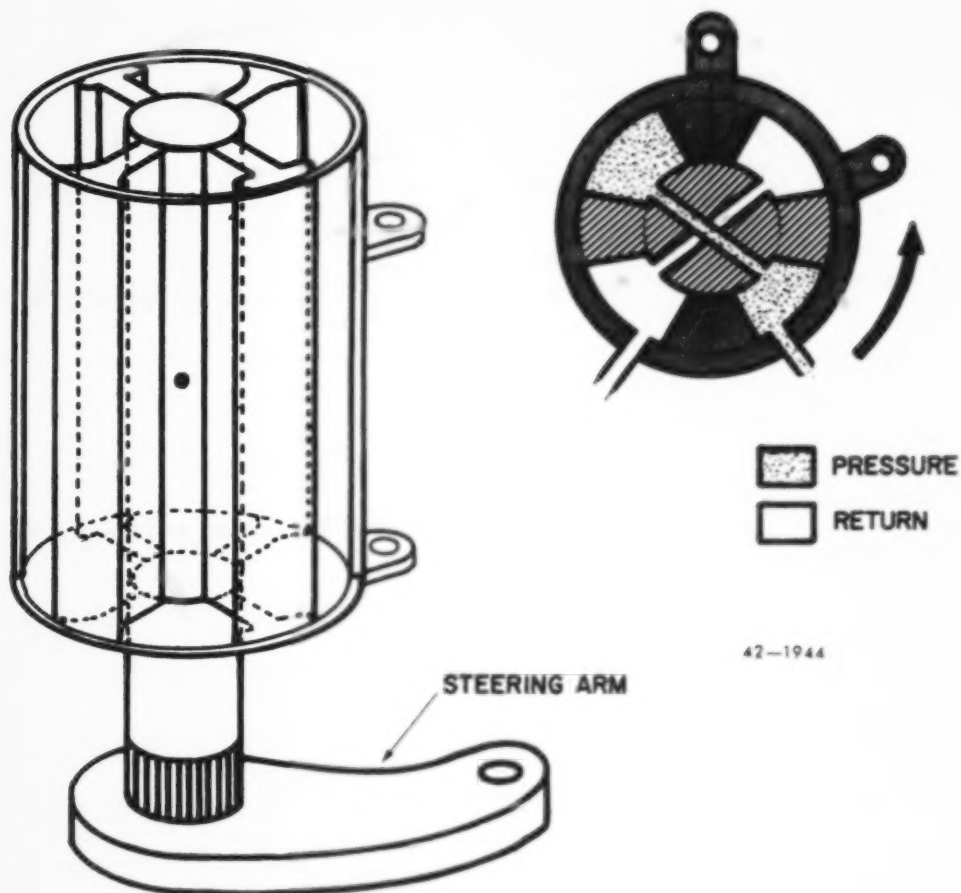


Figure 4-26. Vane actuator.

through splines to a mechanical linkage which, in turn, is connected to a moveable object. To understand how this actuator works, refer to the insert in figure 4-26. Notice that it has two ports, which will allow the attachment of alternating lines. Passages through the wingshaft interconnect various chambers to each other. When pressure is applied, it flows through the wingshaft passages and exerts a force, in this case, counterclockwise. Fluid in the other chambers is forced out the return alternating line and back to the reservoir. We will learn more about vane actuators later on when we talk about shimmy dampers.

Exercises (444):

1. The two types of units primarily used for limited rotary motion are the _____ and the _____ actuators.
2. The vane actuator has _____ and _____ vanes with a _____ extending through the full length of the unit.
3. The items in each of these actuators that will cause an object to move is the _____ in the vane type and the _____ in the rack and pinion.

Subsystem Pressure and Flow Valves

AFTER THE PUMPS produce a fluid under pressure and the selector valves direct it in the proper direction, it may arrive at its destination with either too high a pressure or too much volume. As a result, the actuator may move too fast or the pressure on it may be too great. There are many valves that are designed to aid us in achieving the required results. Flow regulators, pressure reducers, flow equalizers, fuses, and restrictors are just some of the valves that can be used. In some instances, the valve may have two or more names that are commonly used: for instance, a restrictor will sometimes be called an orifice, and a balanced outlet relief valve will sometimes be called a priority valve.

5-1. Flow Valves

There are many valves that are designed to control the flow of fluid through the pneudraulic system. The speed of the landing gear can be controlled by installing orifice check valves in the alternating lines of the system. The orifice check valves will control the amount of flow that is allowed to operate the landing gear. Notice that we are talking about flow in relation to pressure. The pressure throughout the system could be 3000 psi, but the flow will determine the speed of the actuators as it retracts and extends. So, as you can see, there is a definite difference between pressure and flow. Some of the components that will be covered are orifices, flow regulators, flow equalizers, and hydraulic fuses.

445. Match the proper description of various parts of valves with the proper valve.

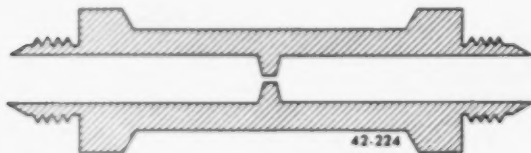


Figure 5-1. Fixed orifice (restrictor).

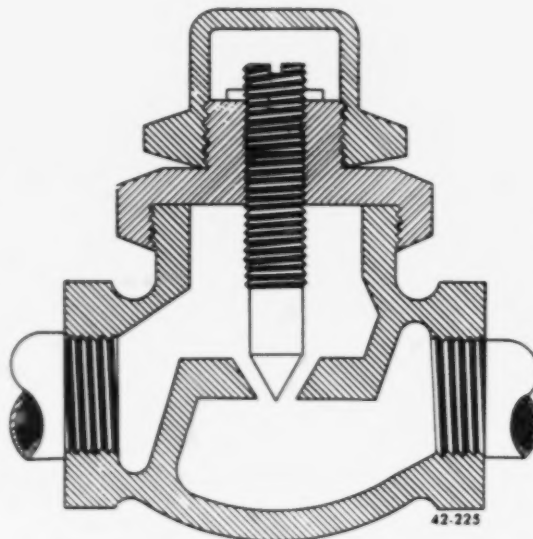


Figure 5-2. Variable orifice.

Fixed Orifices. Orifices are often referred to as restrictors. They are used in systems to limit the speed of movement of such items as the wing flaps and landing gear. They do so by serving as restrictions in the line; they limit the rate of fluid flow. Figure 5-1 shows the construction of a typical fixed orifice.

Variable Orifices. Other types of orifices are constructed so that the amount of restriction can be varied. The type shown in figure 5-2 is built so that you can alter the rate of fluid flow. It lets you adjust the speed or time of operation of a subsystem. Check your TOs for time requirements.

Now, of course, it seems logical to combine the orifice and the check valve.

Orifice Check Valves. Orifice check valves are a combination of an orifice and a check valve. They provide the effects of both in a hydraulic subsystem. They allow normal speed of operation in one direction, but they limit speed in the other. Some typical examples of orifice check valves are shown in figure 5-3.

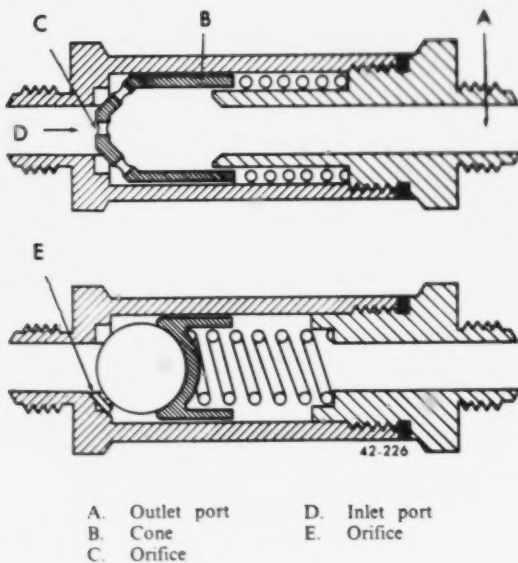


Figure 5-3. Cone and ball orifice check valves.

The top illustration shows the cone orifice check valve. The cone (B) is moved off its seat whenever enough fluid pressure is applied at the inlet port (D). This allows free flow of fluid through the valve and out the outlet port (A). Fluid flows through the valve in the opposite direction, but is restricted by the size of an orifice (C). The bottom illustration of figure 5-3 shows a ball orifice check valve. Fluid flow through the valve from left to right, as shown by the arrow, is normal; fluid flow through the valve the opposite way is restricted by the size of an

orifice (E). The orifice is a drilled passageway located in the housing of the valve.

The orifice check valve is usually installed in the alternating line that carries fluid from the cylinder. It is in this direction of operation that slower movement is desired. It slows down the piston speed because fluid cannot escape from under it any faster than the orifice allows. To illustrate this, let's use the landing gear as an example. The orifice check valve is installed in the "up" alternating line. It allows the fluid to flow freely into the cylinder for rapid retraction of the gear. As the gear is extended, fluid leaving the cylinder must pass through the orifice. Thus, a cushioning effect results, and the gear falls slowly, thereby preventing structural damage. If the restrictor were placed in the "down" line, it would limit the quantity of fluid entering the cylinder and have no effect on the fluid leaving. This is not a good situation because the gear is heavy and tends to fall freely. As a result, a partial vacuum would be created in the cylinder, and the gear would fall too rapidly.

In-Line Filter Restrictors. See figure 5-4. Another type of orifice that is used in hydraulic subsystems is the in-line filter restrictor. It contains two wire mesh finger screens that are installed on either side of the fixed orifice plate. These screens are used to prevent dirt from blocking the hole in the orifice. If these finger screens become clogged, they could cause the subsystem in which they are located to fail.

Exercise (445):

1. Match the orifice in column B to its purpose or operational characteristic listed in column A.

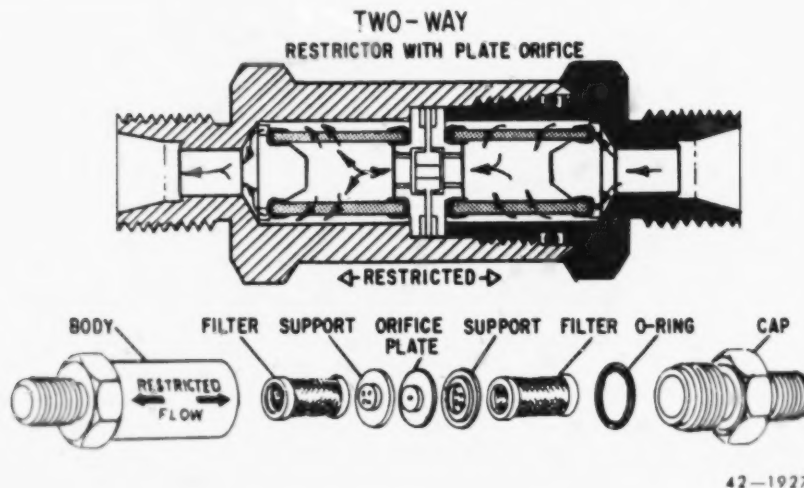


Figure 5-4. In-line filter restrictor.

Column A
Purpose or Operational
Characteristic

Column B
Orifice

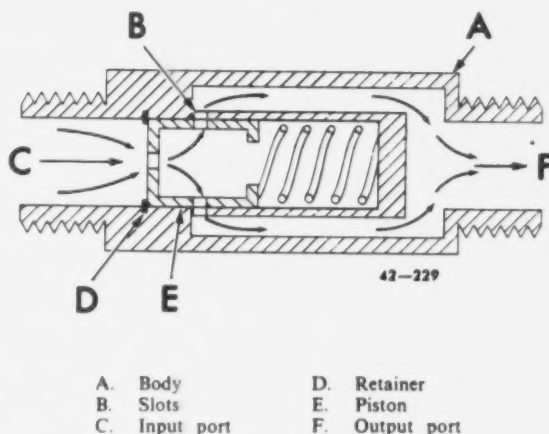
- | | |
|---|-------------------------------|
| — (1) Used to allow free flow in one direction and restricted in the other. | a. Fixed orifice. |
| — (2) Has screen to prevent orifice from being clogged. | b. Variable orifice. |
| — (3) Can be adjusted. | c. Orifice check valve. |
| — (4) Restricts flow in both directions. | d. In-line filter restrictor. |
| — (5) Will be located usually in the "up" alternating lines of a landing gear system. | |

446. Cite the reason a flow regulator would be installed in a pneudraulic system, and specify the operational characteristics of the flow regulator.

Hydraulic Flow Regulators. The flow regulator is sometimes called a constant flow valve or a flow control valve. As in the case with most hydraulic units, the name describes the function of the unit. Any one of its names tells us that its job is to keep the fluid flow at a constant rate. It does this in spite of changes in system pressure or actuator demands.

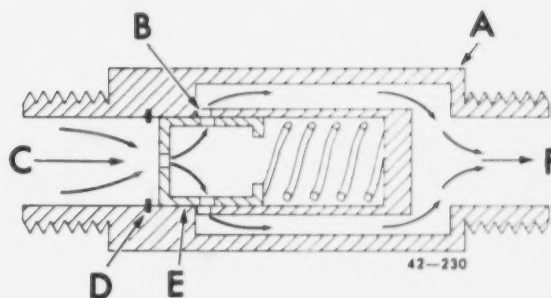
The flow regulator has only one moving part, the piston (E), as shown in figure 5-5. The valve regulates flow only from the input port (C) to the output port (F). If it is installed backwards, it will not regulate. The body (A) of the valve is marked with an arrow to indicate the direction of regulated flow.

Operation of the flow regulator can also be seen in figure 5-5. Fluid enters the input port (C), passes through the orifice in the head of the piston (E), and through slots (B) in the side of the piston. Then it passes out the output port (F). Any increase of pressure in the input port (C) will tend



A. Body
B. Slots
C. Input port
D. Retainer
E. Piston
F. Output port

Figure 5-5. Hydraulic-flow regulator—free-flow condition.



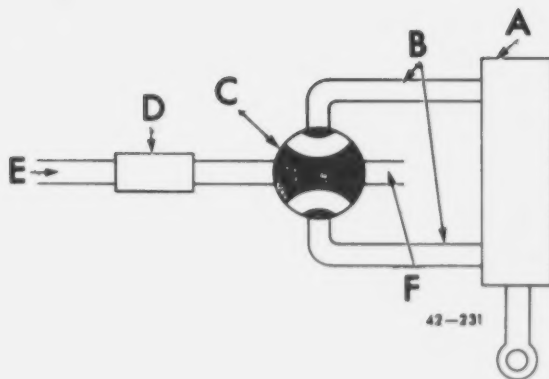
A. Body
B. Slots
C. Input port
D. Retainer
E. Piston
F. Output port

Figure 5-6. Hydraulic-flow regulator—restricted-flow condition

to increase the flow through the orifice in the head of the piston (E). But the difference in pressure between the front and the back of the piston head will increase also. This pressure differential makes the piston move to the right, thereby compressing the spring. When the piston moves to the right, the slots (B) in the piston no longer line up with the holes in the regulator body. (See fig. 5-6.) This places an additional restriction on the fluid to keep it from flowing any faster. The piston can never move right far enough to completely block the ports in the side of the regulator body. Before this could happen, the pressure behind the piston would become equal to the pressure in front of it. The spring, then, will hold the piston to the left enough to keep the ports open. The retainer (D) limits the leftward movement of the piston (E).

An increase in pressure normally increases fluid flow through an orifice, but we see that this is not the case with this flow regulator. As the pressure increases, the size of the openings for fluid flow at the slots (B) decreases. This maintains a constant rate of flow. If the movement of the actuating unit calls for more fluid, the fluid flow starts to increase. An increase in demand by the actuating unit causes a decrease in pressure behind piston the (E). This causes the piston to move to the right; therefore, it decreases the size of the slot opening (B). This prevents an increase in fluid flow to the actuating unit. Thus, our flow regulator maintains a constant rate of flow. It does so regardless of variations in system pressure and regardless of the actuating unit's demands.

An example of typical flow regulator installation is shown in figure 5-7. System pressure enters at the pressure line (E). When the selector valve (C) is positioned, fluid flows through the flow regulator (D). Thus, regardless of the section, one of the alternating lines (B) will have regulated flow through it. This insures a smooth operation of the actuator cylinder (A), either way, at a uniform rate.



- A. Actuating cylinder
- B. Alternating lines
- C. Selector valve
- D. Flow regulator
- E. Pressure line
- F. Return line

Figure 5-7. Hydraulic-flow regulator installation.

Fluid returning to the reservoir goes through the return line (F). These valves are available in different flow capacities and are rated in gallons per minute (gpm).

Exercises (446):

1. Why would a flow regulator be installed in a pneumatic system?
2. When fluid flow increases through the orifice of the piston, what happens to the pressure on the back side?
3. What causes the piston to move as fluid is flowing through the valve?
4. Can the piston move far enough to shut the valve off completely? Explain.
5. How are flow regulators rated?
6. Can this valve be used to regulate flow in both directions?

447. Cite the principle of operation of a flow equalizer; then, from hypothetical situations, specify the way the floating piston must move to equalize flow.

Flow Equalizers. The hydraulic flow equalizer is a unit that hydraulically synchronizes the movement of two actuating cylinders. Remember, synchronize means to move exactly together. To do this, it divides a single stream of fluid from the selector valve into two equal streams. Thus, each cylinder receives the same rate of flow, and both move in unison. The flow equalizer also combines two streams of fluid at an equal rate; therefore, it synchronizes the actuating cylinders in both directions. Since this unit equally divides and combines flow, it is said to be dual acting.

Figure 5-8 shows how the flow equalizer synchronizes the movement of the actuating cylinders in both directions. In the left-hand picture the equalizer is splitting the flow to extend the pistons. The right-hand picture shows the valve combining the two streams coming from the cylinders as the pistons retract. The flow equalizer equalizes the flow, regardless of the pressure required to operate the actuators. Therefore, two cylinders with unequal loads will be properly synchronized.

One type of flow equalizer is shown in figure 5-9. This type is used to divide the pump's fluid output into the two different systems.

If figure 5-9, the flow equalizer is shown in the splitting position. Fluid enters the inlet port (C), where it pushes down the plug (D) and uncovers the two orifices in the sleeve (B). The fluid then splits and tends to flow equally down the two side passages (A and E). It then flows through the two splitting check valves (G and P) and the two metering grooves (K and O) in the valve body. Then it flows out the exit ports (J and N) to the actuating cylinders. Any difference in the rate of flow between the two passages results in a pressure differential between these passages. Then the free-

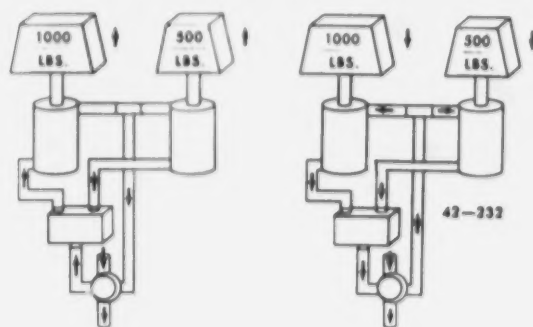
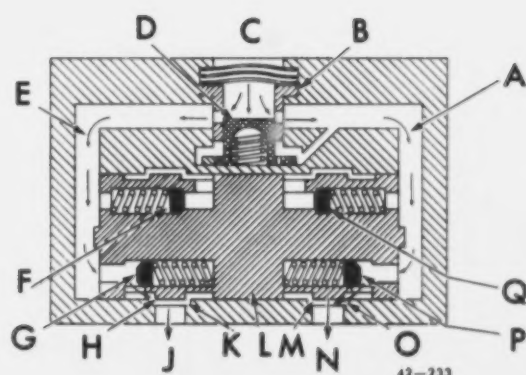


Figure 5-8. Flow equalizer installation.



- A. Side passage
- B. Sleeve
- C. Inlet port
- D. Plug
- E. Side passage
- F. Combining check valve
- G. Splitting check valve
- H. Piston land
- J. Left-hand exit port
- K. Metering groove
- L. Free-floating metering piston
- M. Piston land
- N. Right-hand exit port
- O. Metering groove
- P. Splitting check valve
- Q. Combining check valve

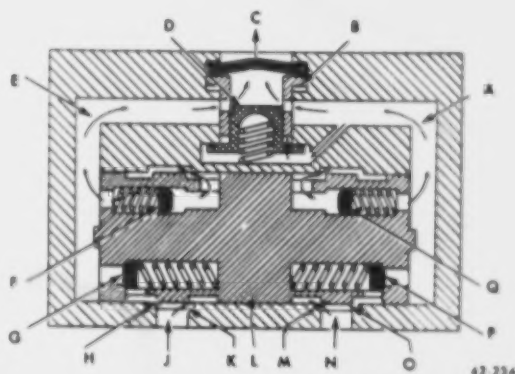
Figure 5-9. Flow equalizer—Splitting position.

floating metering piston (L) shifts to equalize the internal pressures, and the flow equalizes.

To illustrate this equalizing action, let's assume that the actuating cylinder attached to the left-hand exit port (J) moves easier than the one attached to the right-hand exit port (N). The fluid would then try to flow faster out the left-hand exit port, but in doing so it must also flow faster through the left-hand passageway (E). Fluid leaving the right-hand exit port (N) meets with more resistance; so the flow down the right-hand passageway (A) is slower, and its pressure is greater than that of left-hand passageway (E). To explain this, think back to your study of venturi tubes. There you learned the law of physics which states "as the velocity of a gas or liquid increases, there will be a corresponding decrease in pressure (against the walls of the tube)." This momentary pressure differential forces the free-floating metering piston to the left. This causes the space between the piston land (H) and the metering groove (K) to become smaller; the smaller space restricts the flow of fluid out the left-hand exit port (J). Thus, the flow equalizer imposes a restriction on the fluid that has a tendency to flow faster and equalizes the flow in the two streams.

In figure 5-10 the combining position of the flow equalizer is illustrated. This shows the units joining two streams of fluid at the same rate. Here the fluid enters the two ports (J and N) at the bottom of the valve. It cannot get through the splitting check valves (G and P), so it travels around the cylindrical metering piston and enters the combining check valves (F and Q) from the top. The pressure of the fluid opens the check valves and travels up the two side passages (A and E) to the orifice sleeve (B). The fluid pressure gets under the sleeve through a drilled passage and forces it upward. Its upward movement uncovers the orifices and allows the fluid to flow out the inlet port (C).

Again for purposes of illustration, let's assume that the actuating cylinder attached to the left-hand exit port (J) moves easier. Fluid entering that port will then attempt to flow faster. But, as it leaves the check valves and flows up the left-hand passageway (E), it meets the restriction of the orifice. Therefore, if the flow momentarily increases, the orifice will cause an increase in pressure back through the left-hand passageway (E). This will force the metering piston (L) to the right. This causes a restriction between the metering groove (K) and the piston land (M). The fluid which tends to flow fastest has again been restricted.



- A. Side passage
- B. Sleeve
- C. Inlet port
- D. Plug
- E. Side passage
- F. Combining check valve
- G. Splitting check valve
- H. Piston land
- J. Left-hand exit port
- K. Metering groove
- L. Free-floating metering piston
- M. Piston land
- N. Right-hand exit port
- O. Metering groove
- P. Splitting check valve
- Q. Combining check valve

Figure 5-10. Flow equalizer—combining position.

Exercises (447):

1. Cite the principle of operation of the flow equalizer.
2. Use figure 5-9 to answer this question. The left exit port will be attached to a cylinder with a 500 lb load. The right exit port will be attached to a cylinder with a 1000 lb load. In what direction will the free-floating piston move to equalize the flow?
3. Use figure 5-10 to answer this question. The left exit port will be attached to a cylinder with a 1200 lb load. The right exit port will be attached to a cylinder with 200 lb load. In what direction will the free-floating piston move to equalize the flow?
4. Use figure 5-10 to answer this question. Both exit ports are attached to two cylinders with equal pressures. In what direction will the free-floating piston move to equalize the flow?

448. Specify the operational characteristics of the Type I and Type II hydraulic fuses.

Hydraulic Fuses. Some of the newest aircraft cannot fly without hydraulic pressure, the reason being that it is the sole power source for the operation of the flight control surfaces. For this reason, it is necessary to protect the system from complete failure.

A leak in any line or a blown seal in any unit might allow all the fluid to leak out. To prevent total fluid loss from the hydraulic system, a hydraulic fuse is usually used. This valve limits the fluid loss to the amount contained in the small section of the subsystem in which it has been installed.

As its name implies, this unit is similar to an electrical fuse. In an electrical circuit, when too much current flows, the electrical fuse "blows" and opens the circuit. The hydraulic fuse, however, stops the fluid flow when a certain amount of fluid has passed through it. It actually measures the quantity of fluid that is flowing, and for this reason it is sometimes called a quantity-measuring fuse. The size of the orifice in the fuse determines the amount of fluid that will flow through the valve before it fuses. If the orifice is large, the piston will

move faster, allowing less fluid flow through the valve before it fuses. A small orifice causes the piston to move slower; this allows a greater volume of fluid to flow before the valve fuses. The size of the orifice depends upon the amount of fluid needed to move the actuator to its extreme travel. For instance, we have a landing gear actuating cylinder that needs 40 cubic inches of fluid for the piston to be fully extended. In this cylinder line we would install a fuse with a 45-cubic inch capacity, for example. We always use a fuse with a slightly larger capacity than the actuator requirement. This insures that the valve will not fuse before the cylinder has reached its full limit of travel. Since the orifice cannot be removed from a fuse, we have fuses with orifices of different sizes. Figure 5-11 shows the two methods of installing the fuse in the hydraulic system. The fuse will measure flow in only one direction. For this reason the hydraulic fuse must either be installed in the pressure line to the subsystem or be located in each alternating line after the selector valve. Hydraulic fuses come in two types: Type I, which is automatic reset; and Type II, which needs to have a reverse flow in order to reset it. We will discuss each type in detail.

Type I fuse. Figure 5-12 shows a cutaway schematic of the hydraulic Type I fuse in the static

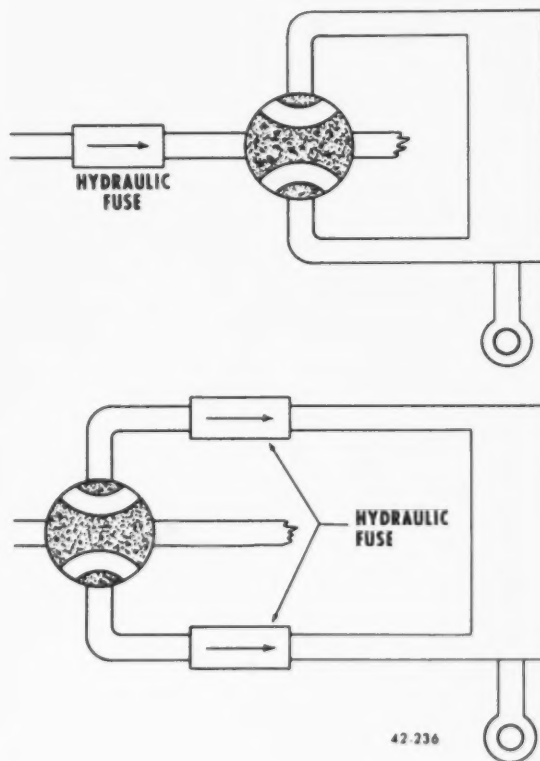
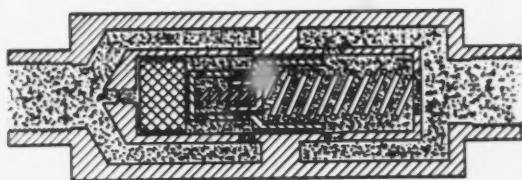
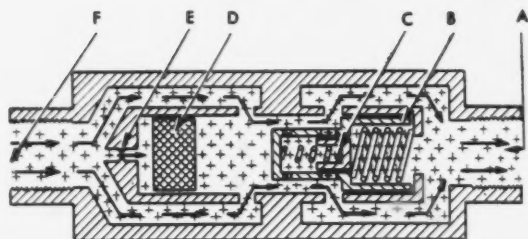


Figure 5-11. Hydraulic fuse installation.



42-235

Figure 5-12. Hydraulic fuse—static condition.



42-237

- | | |
|----------------|---------------|
| A. Exit port | D. Piston |
| B. Sleeve | E. Orifice |
| C. Check valve | F. Inlet port |

Figure 5-13. Hydraulic fuse—normal flow.

position. In this position, there is no flow of fluid in either direction. This is the position the valve assumes whenever the system it protects is not in operation. When fluid is flowing, however, it measures the flow from left to right.

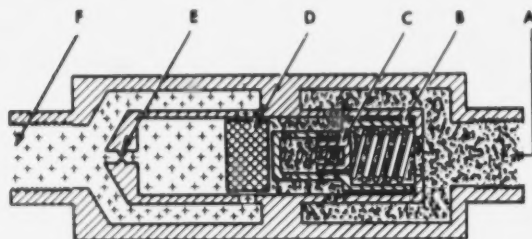
In figure 5-13 we see the hydraulic fuse in the flow position. The fluid enters the inlet port (F). There it splits, flowing along the side passages and on to the center of the valve through the drilled holes. Here it pushes the sleeve (B) back, letting fluid pass out the other holes, around the outside passages, and out the exit port (A). While this is going on, some of the fluid entering the inlet port (F) goes through the small orifice (E). This fluid slowly pushes the piston (D) back. This happens because there is less pressure on the back side of the piston than on the front. If more fluid flows than is normally required for one actuator operation, the piston will have moved all the way back until it hits the sleeve (B). (One normal operation, will not move it that far.) In this position, the piston blocks the holes drilled through the outer passages. Now fluid flow from the exit port (A) stops. In this position, the valve is fused. (See fig. 5-14.) Remember that fluid flows through the fuse continuously until the piston moves back far enough to block the holes. Thus, the amount of

fluid flow before the valve fuses depends upon the time it takes the piston to move to the right.

The check valve (C) is used to permit reverse fluid flow should the fuses be connected in alternating lines. Figure 5-15 shows this reverse flow condition with the check valve open. During reverse flow the check valve (C) is pushed back to open side ports in the sleeve (B). Both the sleeve (B) and the piston (D) are pushed back to their original static position.

During normal operation, the valve nearly fuses each time the full actuator capacity flows through it. When the fluid flow stops, pressure equalizes in all parts of the fuse. Then the large spring forces the sleeve and piston back to the static position. The fuse also "resets" to the static position after it has fused by equalizing the pressure on each side of the fuse.

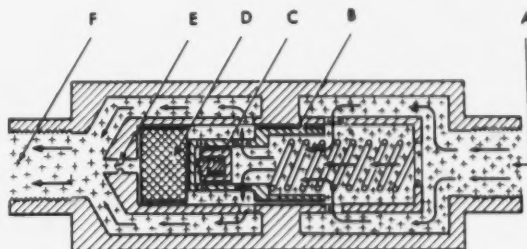
Type II fuse. The Type II fuse works basically the same as the Type I fuse, except that, once the fuse has set, it is locked in the fused position until a reverse flow releases it. Figure 5-16 shows a



42-238

- | | |
|----------------|---------------|
| A. Exit port | D. Piston |
| B. Sleeve | E. Orifice |
| C. Check valve | F. Inlet port |

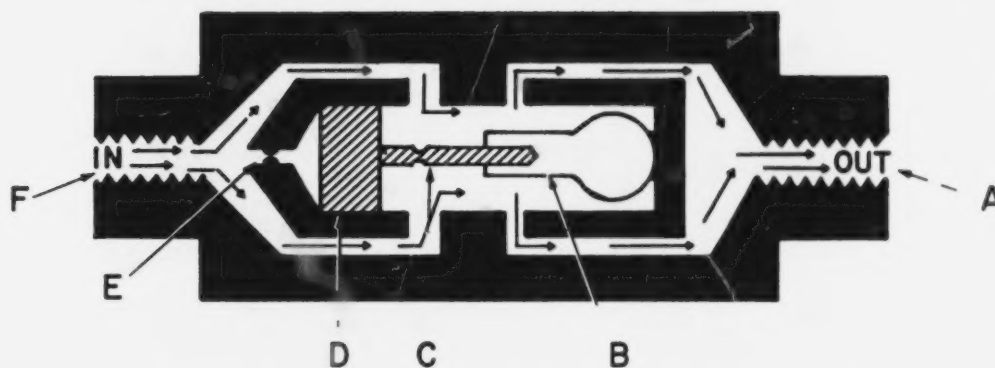
Figure 5-14. Hydraulic fuse—fused condition.



42-239

- | | |
|----------------|---------------|
| A. Exit port | D. Piston |
| B. Sleeve | E. Orifice |
| C. Check valve | F. Inlet port |

Figure 5-15. Hydraulic fuse—reverse flow.



42-1931

- | | |
|----------------|---------------|
| A. Exit port | D. Piston |
| B. Lock spring | E. Orifice |
| C. Stop rod | F. Inlet port |

Figure 5-16. Type II fuse—normal flow.

simplified illustration of a Type II fuse in the flow position. The fluid enters the inlet port (F). There it splits, flowing along the side passages and on out to exit port. While this is going on, some of the fluid entering the inlet port (F) goes through the small orifice (E). This fluid slowly pushes the piston (D) to the right. If more fluid flows than is normally required for one actuation, the piston will have moved all the way to the right until it blocks the holes drilled through the outer passages. Now fluid flow from the exit port (A) stops. Notice that the piston has a stop rod (C) attached to it. Also notice that it has a groove for the lock spring (B) to slide into. When the fuse is in this fused position (see fig. 5-17), the lock spring will hold the piston even if you drop pressure off the complete system. The only way to reset this type of fuse is to force fluid into the outlet port. The fluid pressure entering through the exit port (A) will apply enough pressure to the piston to release the lock spring and move the piston back to the static position.

Each fuse has the flow capacity and the type clearly marked on its body. Don't use the wrong type or one of incorrect flow capacity.

Exercises (448):

1. State the purpose of a quantity-measuring fuse.
2. What does the size of the orifice determine?
3. Refer to figure 5-13. What causes the piston to move to the right?
4. What purpose is served by the check valve? Refer to figure 5-13.
5. During normal operation, does the Type I valve fuse each time the full actuator capacity flows through it? Explain.
6. Which fuse is automatically reset?
7. What fuse must use reverse flow to reset it?
8. What valve is held in the fuse position by lock spring and stop rod?
9. What valve is held in the fused position by hydraulic pressure only?

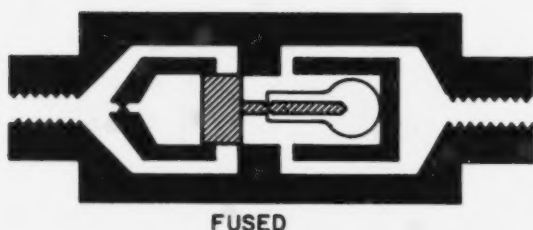


Figure 5-17. Type II—fused condition.

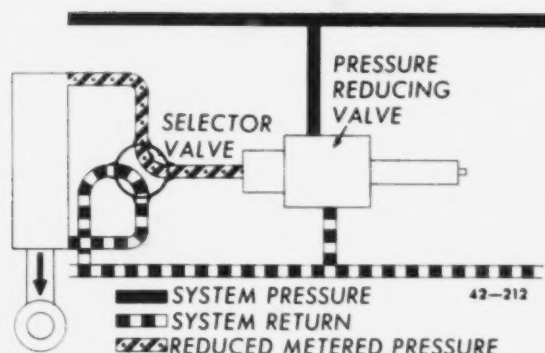


Figure 5-18. Typical installation of a pressure-reducing valve.

5-2. Pressure Valves

There are times that the pressure of a hydraulic system must be reduced in order to operate a specific component. Another factor to consider is that in modern aircraft one system, such as the landing gear, can be operated from several power supply systems. This was done to allow the system to function in the event its normal power supply system failed; however, some way had to be developed to separate the power supply systems.

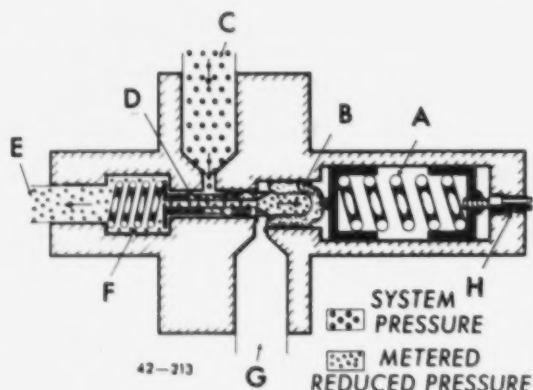
In this section, we shall cover the valves used to accomplish these tasks, namely the pressure reducer and the shuttle valve. We shall also cover some of the common ways of sequencing system operation on simple schematics. We hope this will give you a better understanding of how these sequenced systems operate. Finally, we will cover swivels, which, although very simple, cause quite a lot of leakage problems.

449. Given hypothetical pressure readings, specify the operation of a pressure reducer.

Pressure-Reducing Valves. We have learned that pressure regulators can maintain system pressure between two limits and that relief valves can limit maximum pressure. Yet, in certain situations these units may not meet our needs. In some section of

the system, we may not want to use full system pressure. It may be that the actuator in a subsystem is not designed for the high pressure we have in the system. Or perhaps we want a reduced operating pressure to prevent overloading some structure. Whatever the reason, a pressure-reducing valve is what we need. This valve will reduce system pressure to the desired level; it will also relieve thermal expansion in the section of the system that it isolates. In figure 5-18 we see how a pressure-reducing valve is installed in a system. It brings about a lower pressure for operation of the actuating cylinder.

The pressure-reducing valve has three ports. (See fig. 5-19.) One of these (C) is connected to system pressure, one (G) to the system return line, and the third (E) is the reduced-pressure port. Figure 5-19 shows the valve as it reduces pressure. The pressure-adjusting spring (A) holds the reservoir return valve (B) and the poppet (D) to the left. Fluid under system pressure enters the system pressure port (C). It passes around the unseated poppet and out the reduced-pressure port (E). Soon the pressure going out the reduced-pressure port (E) builds up. The pressure is transmitted back through the hollow poppet (D) and exerts a force on the reservoir return valve (B). When this force overcomes pressure-reducing spring (A) force, the reservoir return valve is pushed to the right. Now the poppet spring (F) seats the poppet. This stops the system pressure which was going out the reduced-pressure port (E) from building up further pressure there. The inlet pressure (C) has no effect on the poppet itself. The reason is that the areas on the ends of the poppet exposed to the pressure are the same; therefore, the forces exerted on the



- | | |
|-----------------------------|-----------------------------|
| A. Pressure-reducing spring | E. Reduced-pressure port |
| B. Reservoir return valve | F. Poppet spring |
| C. System pressure port | G. Reservoir return port |
| D. Poppet | H. Pressure-adjusting screw |

Figure 5-19. Pressure-reducing valve.

poppet are balanced. The pressure exerts an unbalanced force only on the area of the reservoir return valve (B).

In actual operation, this pressure-reducing valve will close when the desired pressure is reached and held. But in continuing operation of the actuator using the reduced pressure, the valve will vary its opening. It varies its opening to meter the fluid at the speed required to maintain the desired pressure.

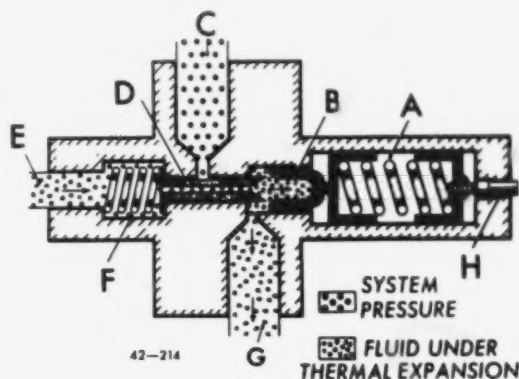
Figure 5-20 is the same as figure 5-19 except that it shows a static condition. If the actuator is not in use, no fluid flows. The fluid between the reducing valve and the selector valve is trapped. If thermal expansion occurs in this line (port E), the increased pressure will push the reservoir return valve (B) to the right. This movement allows a small amount of fluid to be relieved out the return port (G). Then the spring will close the return valve (B), and the fluid will be trapped at the proper pressure again.

The pressure-reducing valve has a pressure-adjusting screw (H) to change the reduced pressure. Turning the screw counterclockwise increases the adjusting spring (A) pressure. This increases the metered pressure.

Exercises (449):

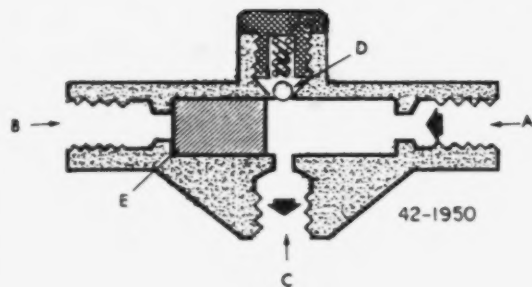
The following operations of a pressure reducer will be based on a pressure reducer which is adjusted to reduce pressure from 3000 to 1500 psi.

1. If the main system pressure drops to 2000 psi, how much pressure will be allowed to flow to the subsystem with a pressure reducer?



- | | |
|-----------------------------|-----------------------------|
| A. Pressure-reducing spring | E. Reduced-pressure port |
| B. Reservoir return valve | F. Poppet spring |
| C. System pressure port | G. Reservoir return post |
| D. Poppet | H. Pressure-adjusting screw |

Figure 5-20. Pressure-reducing valve relieving thermal expansion.



- | |
|--------------------------------|
| A. Normal system inlet port |
| B. Emergency system inlet port |
| C. Outlet port |
| D. Position-retaining ball |
| E. Shuttle |

Figure 5-21. Shuttle valve.

2. What will happen if thermal expansion buildup in the subsystem with a pressure reducer?
3. If an actuator is not being used, what will the pressure reading be in the subsystem?
4. If the main system pressure builds up to 3450 psi, how much pressure will be allowed to flow to the subsystem?

450. Indicate whether given statements concerning a shuttle valve are correct.

Shuttle Valve. The purpose of the shuttle valve is to separate one system or part of a system from another—for example, to separate the emergency system from the normal system, or one main system from another. To allow operating pressure to reach the actuating unit and still not enter the other system, a shuttle valve is installed in the working line to the actuating unit. Shuttle valves are located as close as can be to the unit to be actuated, and in some installations the shuttle valve is an integral part of the actuating unit. This will reduce the number of units and lines to be bled when air is used as the alternate source of pressure.

A typical shuttle valve is shown in figure 5-21. The body contains three ports—the normal system inlet port (A), the emergency system inlet port (B), and the unit outlet port (C), which is the cylinder port. Inclosed in the body is a sliding part called the shuttle. It is used to seal one of the two inlet ports. A shuttle seat is installed at each inlet port;

and, during operation, the shuttle is held against one of these seats, preventing leakage out that port. Some shuttle valves have a shuttle spring, but the one in figure 5-21 does not. Instead, it has a shuttle position-retaining ball and spring. This prevents the shuttle from flopping around inside the body during hard landings.

In figure 5-21 you can see that fluid can enter the normal inlet port (A), which forces the shuttle (E) to the left against the emergency inlet port (B). The shuttle will be held there by the pressure and the position-retaining ball (D). Fluid can now flow through the normal inlet port (A) and flow out the outlet port (C). However, when normal system pressure is lost and the emergency system is operated, fluid enters emergency inlet port (B). This forces the shuttle to the right, blocking the normal inlet port (A). This prevents emergency fluid from escaping into the normal system. Now the emergency fluid has a path for flow into the actuator.

Shuttle valve maintenance is generally limited to repairing leakage. External leakage may usually be repaired by replacing seals on end caps. Internal leakage can usually be repaired by removing the unit and flushing it with clean hydraulic fluid. This will remove foreign matter from the seating areas of the shuttle. Excessive heating is a good indication of internal leakage through a shuttle valve.

Exercises (450):

Indicate whether the following statements concerning a shuttle valve are correct by placing a T for a true statement or an F for a false statement in the blank provided. Correct the false statements.

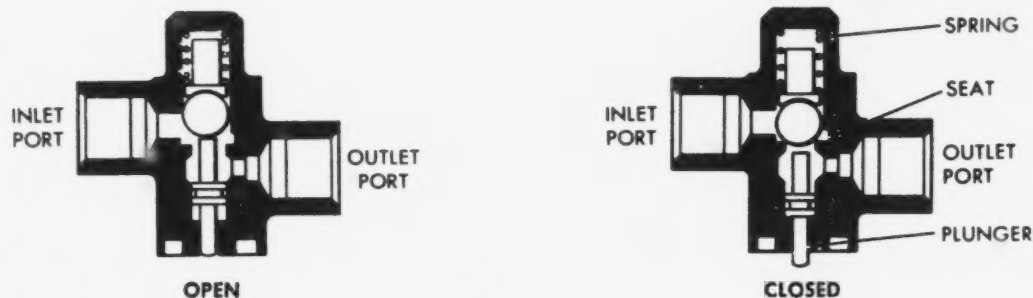
- 1. Shuttle valves are used to separate two individual systems from each other.

- 2. Shuttle valves are usually located as close to the power pump as possible.
- 3. The shuttle valve usually has four ports.
- 4. The shuttle retaining ball alone holds the shuttle up tight against the shuttle seat.
- 5. Flopping of the shuttle is prevented by the shuttle position ball and spring.
- 6. The shuttle is the only moving part.

451. Cite three methods of sequencing, then specify the operational characteristics of each sequencing system.

Sequencing Systems. In some systems, one operation must be performed before the rest of the system can operate. Therefore, the operation of the various system units must occur in proper sequence. Control of a sequenced system is applied by mechanical, electrical, or hydraulic means. Devices such as microswitches, priority valves, and hydraulic sequence valves are used in sequenced systems.

Mechanically sequenced system. A mechanically sequenced system uses a sequence valve to insure proper operational sequence. Figure 5-22 shows a sequence valve. Notice that it has two ports, an inlet and an outlet. Notice also that it has a ball, a spring, and a plunger. When the valve is closed, the



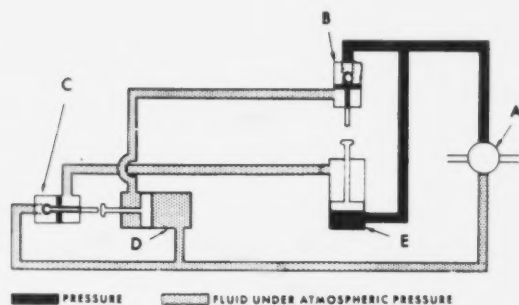
42-1926

Figure 5-22. Sequence valve.

spring forces down on the ball, keeping it on seat. Fluid cannot flow through this valve when it is in this position. Now notice the valve in the open position; as you can see, the plunger has forced the ball off its seat, compressing the spring. Fluid can now flow from the inlet port to the outlet port. In the following paragraphs, we will see how this plunger is actuated to open the sequence valve.

Let us consider a simple landing gear system incorporating wheel well doors, as shown in figure 5-23. It is clear that the doors must not close before the gear is retracted. Also, the doors must open before the landing gear is extended. Let us suppose that the pilot has positioned the selector valve (A) to retract the landing gear. Pressure is then directed to the Up side of the landing gear actuating cylinder (E). At the same time, pressure goes to the landing gear sequence valve (B). At this time, the sequence valve (B) is closed. Therefore, pressure can flow only to the UP side of the landing gear actuating cylinder (E). The door sequence valve (C) is in the OPEN position to allow the return flow from the actuator to the reservoir. As the retraction nears completion, the actuating cylinder starts to position the landing gear sequence valve (B). This occurs when the piston rod in the landing gear actuating cylinder (E) extends far enough to contact the piston rod of the landing gear sequence valve (B). As the piston of the sequence valve moves, it pushes the ball off its seat and opens the valve. Fluid under pressure is now allowed to flow to the door actuating cylinder (D).

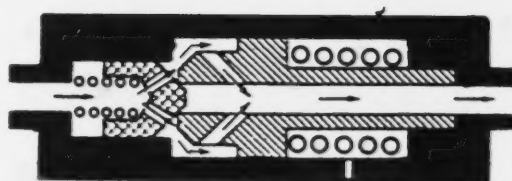
As the doors close, the actuator linkage draws away from the rod in the door sequence valve (C). It releases the spring-loaded piston rod of the door sequence valve (C), which closes the valve. During gear extension, the selector valve (A) first directs



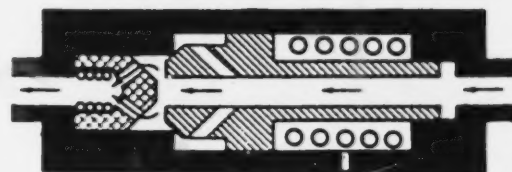
42-140

- A. Selector valve
- B. Sequence valve closed (landing gear)
- C. Sequence valve open (door)
- D. Actuating cylinder (door)
- E. Actuating cylinder (landing gear)

Figure 5-23. Mechanically sequenced system.



A. RELIEF FLOW



B. REVERSE FLOW

42-1916

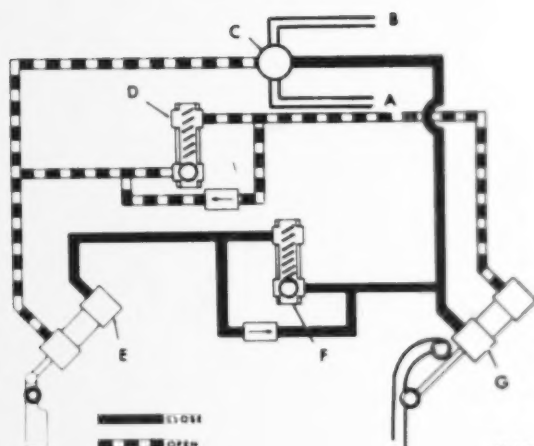
Figure 5-24. Priority valve.

pressure to the door actuating cylinders. When the doors are open, mechanical contact is made with the door sequence valve (C) and opens it. This allows the fluid pressure to continue on to the landing gear actuating cylinder (E) to extend the gear. Return fluid from the door actuating cylinder (D) is routed through the landing gear sequence valve (B), which is still open.

Pressure-sequenced system. This type of sequencing is done with a balanced relief valve, better known as a priority valve.

Figure 5-24 shows a priority valve. The large spring forces the piston on seat with the check valve and housing. As long as the inlet pressure is below the setting of the valve, fluid cannot flow from the inlet port to the outlet. When pressure builds up above the setting of the priority valve, the piston will move to the right, as shown in figure 5-24, A. Fluid can now flow from the inlet port past the check valve through the holes in the piston, then out into the system. Reverse flow is shown in figure 5-24, B. As you can see, fluid flows from the outlet port through the piston to force the check valve off seat, then through the check valve holes and to the inlet port. To show how this valve can be placed in a system, see figure 5-25. It illustrates a bomb bay door system which uses spoilers to protect the bomb bay doors from the air stream.

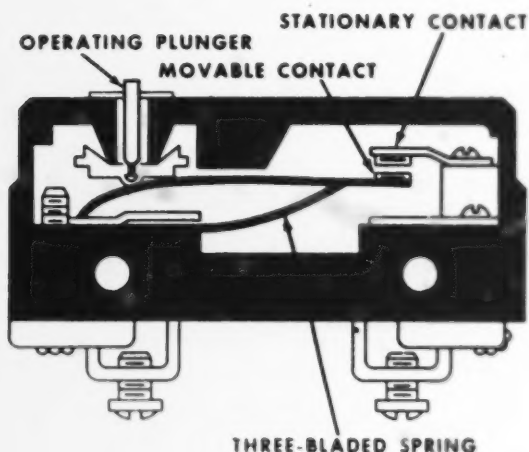
With the selector valve (C) in the OPEN bomb door position, pressure is sent to the OPEN side of the spoiler actuator (E). It is also sent to the priority valve (D). The pressure needed to operate the spoilers is less than that required to open the priority valve. Therefore, the pressure can increase only after the spoilers are open and no more piston travel is possible. Then it can increase to the setting



42-141

- A. Return line
- B. Pressure line
- C. Selector valve
- D. Relief (priority) valve
- E. Spoiler actuating cylinder
- F. Relief valve
- G. Bomb door actuating cylinder

Figure 5-25. Pressure sequence system.



42-1925

Figure 5-26. Microswitch.

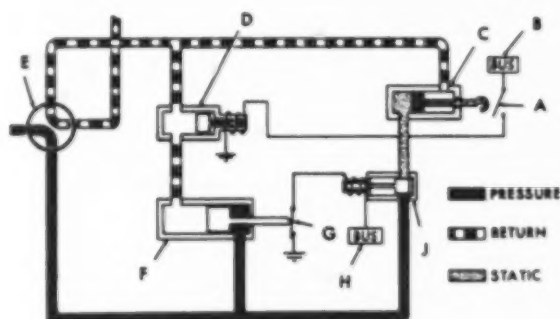
of the priority valve. When the priority valve opens, pressure is applied to the bomb door actuator to open the doors.

When the selector valve is turned to CLOSE, pressure (now represented by the solid line) is directed to the CLOSE side of the actuator (G). At the same time, pressure also goes to the priority valve (F). The pressure required to close the doors is less than the pressure settings of the priority valve. When the doors are closed, the pressure

continues to increase until it opens the priority valve. Once the priority valve opens, pressure can close the spoiler actuator (E). A check valve is used in conjunction with each priority valve so that returning fluid from the actuators can continue, unrestricted, through the selector valve to the reservoir.

Electrically sequenced system. In a hydraulic system with electrically sequenced valves, the control is a solenoid or motor. The electricity to the valves is controlled by microswitches. The microswitches are actuated by the hydraulic units of the system in which they are located.

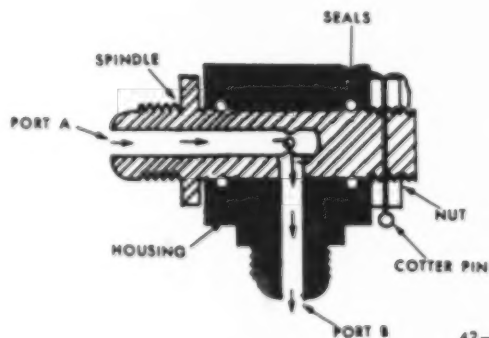
Microswitches are miniature switches with a very small movement of the tripping device (1/16 inch or less); hence the name "micro," which means



42-143

- A. Microswitch
- B. Source of electrical power
- C. Center latch
- D. Shut-off valve
- E. Latch selector valve
- F. Jamb latch actuator
- G. Microswitch
- H. Source of electrical power
- J. Shut-off valve

Figure 5-27. Electrical sequence system.



42-1937

Figure 5-28. Simple swivel.

small. These switches can be made so that the contacts are normally opened or closed. To see how these switches operate, notice the normally closed microswitch shown in figure 5-26. When the operating plunger is pushed in, the spring is pushed down; the moveable contact, which is attached to the spring, is separated from the fixed contact, and the circuit is opened. Microswitches can be used to operate a system like the one in figure 5-27. Placing the latch selector valve (E) to the UNLATCH position directs pressure to the jamb latch actuator (F) and to the shut-off valve (J). The shut-off valve (J) is energized in the closed position by the closed position of the microswitch (G). This prevents hydraulic pressure from going to the center latch actuator (C). As the jamb latch actuator (F) moves to the unlatch position, the microswitch (G) opens and deenergizes the shut-off valve (J). This opens the shut-off valve (J) and allows pressure to go to the center latch (C). (The shut-off valve switch (G) cannot be opened until the jamb latch is completely open.) As the center (C) latch opens, its piston rod closes the shut-off valve switch (A). This energizes and closes the shut-off valve (D). This completes the unlatching of the doors. Other hydraulic valves and actuators are used to open the doors and lower the ramps.

Exercises (451):

1. List three types of sequencing.
2. Which type of sequencing unit is used for sequencing a mechanical system?
3. What is the purpose of installing sequence valves in a system?
4. Refer to figure 5-23. If the actuating door is moving to the left, in what position is the sequence valve (B)? In what position is the actuator (E)?
5. Refer to figure 5-25. If the actuator (G) is extending, in what direction is the fluid flowing through the priority valve (D)?
6. Refer to figure 5-25. In what position is the actuator (E) if fluid is flowing freely through the check valve of the priority valve (F)?
7. Refer to figure 5-27. Is the shut-off valve (D) energized open or closed?
8. With the microswitch (G) closed, in which direction is the actuator (F) moving? In which direction is the actuator (C) moving?

452. State the purpose of swivel joints, and specify their operational characteristics.

Swivel Joints. A variety of swivel joints are used throughout hydraulic and pneumatic systems to provide the use of rigid tubing between moveable parts. For instance, if a landing gear actuating cylinder has to rotate during the raising and lowering of the gear, then a swivel joint could be incorporated in the system. One type of swivel joint is designed as shown in figure 5-28. It consists of a housing (body), spindle, seals, nut, and cotter pin. The swivel is provided with two ports, which we will call Ports A and B for explanation purposes only. Hydraulic fluid enters port A and flows through the hollow center of the spindle. In the middle of the spindle are some holes that allow the fluid to enter the housing and then exit through port B. The spindle is allowed to rotate 360° around the lateral axis of the housing. The seals in the housing prevent leakage between the spindle and the housing.

When assembling swivels, gently push the housing over the spindle with a slight oscillating motion to prevent damage to the O-ring seals. Test for pressure by applying pressure to one port while the other port is capped. Maintain the pressure for at least 2 minutes; there should be no leakage. Conduct this test a minimum of three times; during the test, rotate the swivel through a complete swiveling circle. Check the torque required to rotate the swivel against the technical order. Next, make a static leak check, using only a small amount of pressure. After you complete this test, remove the cap from the capped port and apply low pressure, checking to see that fluid flows freely through the swivel.

Another type of swivel used is called a balanced extension unit. It not only rotates 360° around its lateral axis, but it will extend and retract also. Balanced extension units similar to the one illustrated in figure 5-29 are used in place of flexible hose to transfer fluid pressure from a fixed

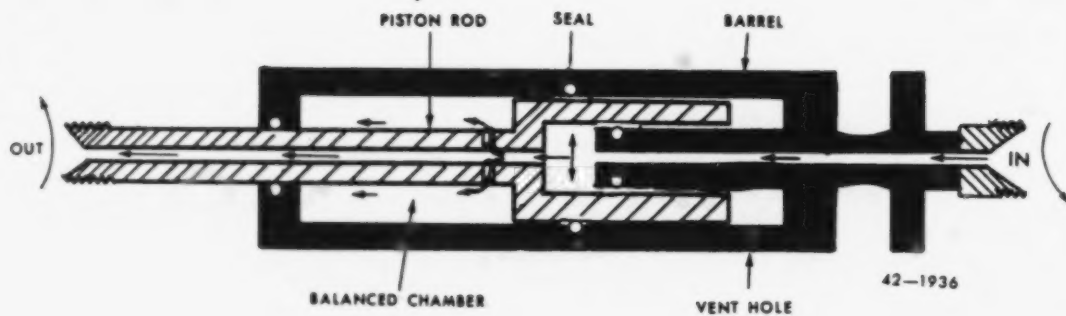


Figure 5-29. Balanced extension unit.

point to a moveable point. Each unit is a pressure balanced extension tube, consisting of a barrel and a piston rod. The piston rod slides in and out of the barrel. With fluid flowing in the inlet port of the extension unit, pressure flows up through the holes in the piston rod into the balanced chamber. The areas on which the pressure acts are equal, resulting in a balancing of the forces exerted. The pressure-balanced feature results in friction's being the only force which must be overcome in extending or retracting the unit. A vent hole lets air enter and exit as the piston is moving in and out of the barrel. This hole should be pointed down whenever the unit is installed so that leakage past the O-ring seals can escape.

Exercises (452);

1. What is the purpose of the swivel joint?

2. What is the advantage of a balanced extension unit over simpler swivels?
3. Refer to figure 5-28. What components prevent leakage between the spindle and the housing?
4. Refer to figure 5-29. What is the only force that must be overcome in order to extend or retract the unit?
5. Refer to figure 5-29. What unit slides in and out of the barrel?

Landing Gear Components

THE LANDING speeds of aircraft are constantly increasing, particularly those of jet aircraft, which touch down on the runway at more than 110 mph. This increase has been brought about by the use of very efficient high-speed wings. However, these same wings have very poor lift characteristics, such as their tendency to stall and generally provide poor lateral control at low airspeeds. These conditions place severe loads on the landing gear and its components during each landing. To successfully complete any aircraft mission, the landing gear system must be in top notch condition.

Faulty gear retraction or extension, improperly operating shock struts, structural failures, or defective tires can cause serious damage to an aircraft. And still worse, these failures can cause injury or possibly death to the crew. Therefore, it is important that you understand the operation of landing gears and their components. Accordingly, this chapter is devoted to shock struts, shimmy dampers, steering damper units, and brake system components.

6-1. Shock Struts

The aircraft shock struts are similar to the shock absorbers you have on your car, except that they are much more complicated. On very early aircraft they didn't have shock struts as we know them today. They used the normal flexing of the airframe along with bungee cord (elastic cord) to absorb the shock of landing. Of course these items could not used on the heavier, faster flying aircraft we have today. Since there are many different designs of shock struts, only information of a general nature can be included in this section. For specific information on a particular installation, refer to the applicable aircraft technical order.

453. Match components of a typical shock strut to their functions.

Typical Shock Struts. Shock struts are self-contained hydraulic units. They carry the burden of supporting the aircraft on the ground and protect the aircraft structure by absorbing the tremendous shock of landing.

As shown in figure 6-1, the shock strut is made up essentially of two telescoping cylinders. They are the outer cylinder and the inner cylinder, which is sometimes called the piston. The two cylinders, when assembled, form an upper and a lower chamber, which are separated by the orifice. The lower chamber is always filled with fluid; the upper chamber contains fluid and compressed air (nitrogen). Most shock struts employ a metering pin to control the rate of fluid flow through the orifice. Notice the shape of the metering pin. On other types of shock struts, a metering tube replaces the metering pin, but shock strut operation is the same.

Some shock struts are equipped with a snubbing device consisting of a recoil valve on the piston. It is nothing more than a restrictor check valve. Its purpose is to reduce the rebound during the extension stroke and to prevent a too rapid extension of the inner cylinder, which would result in a sharp impact at the end of the extension stroke.

The tire is installed on the axle, which is attached to the lower part of the inner cylinder. A follower, or bumper ring, incorporated in the strut limits the extension stroke.

The lower bearing is designed to hold the seals which are used to prevent external leakage between the upper and lower cylinders. A felt wiper is used to lubricate the piston as it slides in and out of the outer cylinder. A scraper ring is also installed under the lower bearing to keep the sliding surface of the piston or inner cylinder free from dirt, mud, ice, and snow. Entry of foreign matter into the seals would result in leaks.

An air filler valve is located near the upper end of each shock strut to provide a means of filling the strut with hydraulic fluid and inflating it with air. A strut cap is used to hold the orifice support tube, and it also has seals to prevent external leakage at the upper end of the strut. The orifice support tube is a tube with holes in it to let the fluid pass freely into the center of the tube. The orifice can be found at the lower end of the tube. The gland nuts are used to hold the lower bearing and support tube plate in place. The trunnion, which is located at the upper end of the outer cylinder, is used to mount

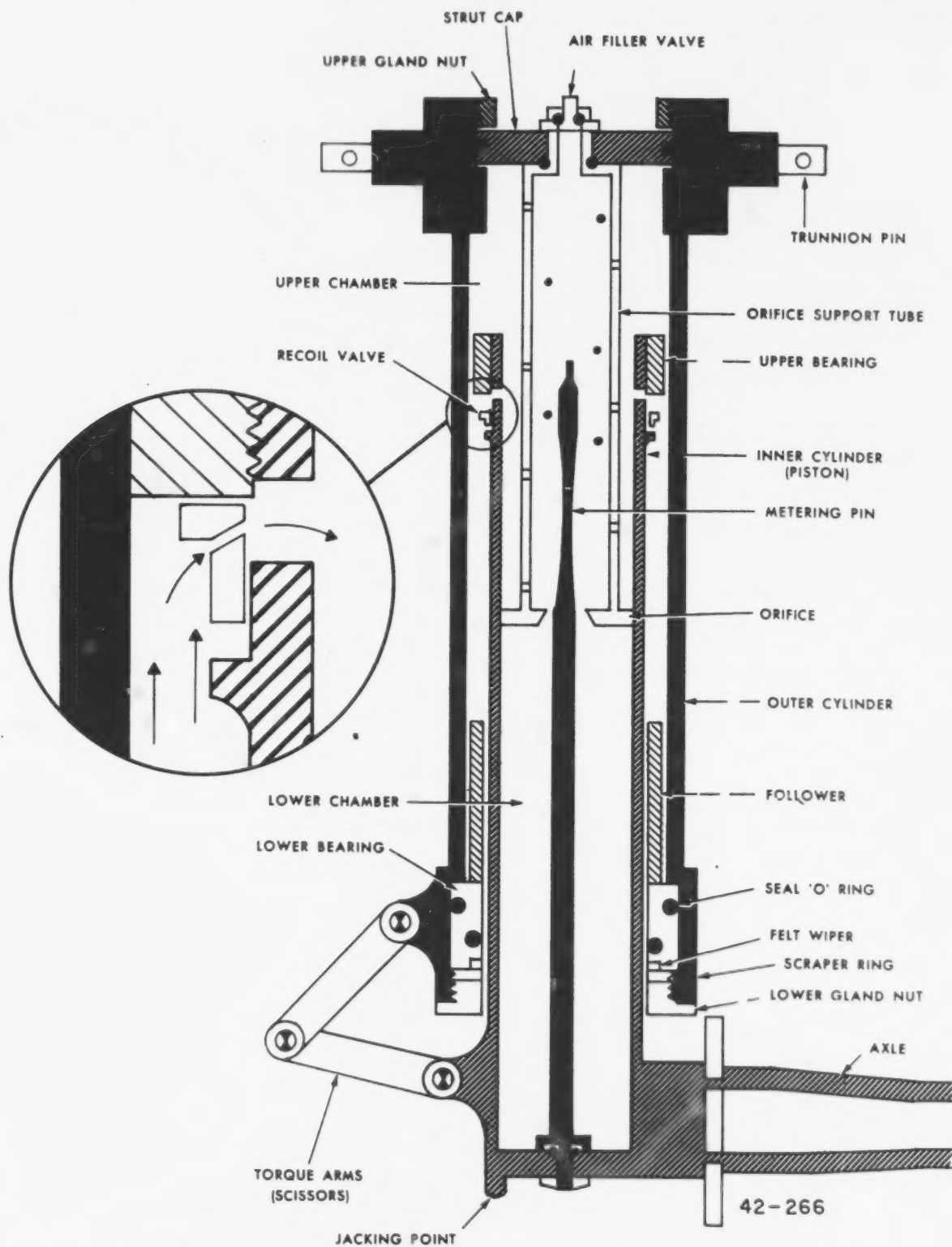


Figure 6-1. Main gear strut.

the shock strut in the aircraft. The upper bearing, which is attached to the inner cylinder, is used to maintain correct alignment and minimize friction on the cylinder surfaces.

Torque arms attached to the inner cylinder and outer cylinder are used to maintain correct alignment of the wheel. They do this by preventing the inner cylinder from rotating within the outer cylinder. On some nose gear shock struts, the torque arms are used to transmit the force from the nose steering unit to the inner cylinder. Shock struts are provided with jacking points to facilitate maintenance such as tire or brake changes. Jacks should always be placed under the prescribed points to prevent damage to equipment or injury to personnel.

Exercise (453):

- Using figure 6-1, associate the functions in column A with the individual parts of the strut in column B with its name. There may be more than one answer for each function.

<i>Functions</i>	<i>Column A</i>	<i>Column B</i> <i>Name of Part</i>
— (1) Separates the upper and lower chambers.		a. Air filler valve.
— (2) Contains fluid and air.		b. Upper chamber.
— (3) Controls the rate of fluid flow through the orifice.		c. Trunnion pins.
— (4) Is a restrictor check valve.		d. Orifice support tube.
— (4) Is a restrictor check valve.		e. Upper bearing.
— (5) The wheel and tire are attached to it.		f. Metering pin.
— (6) Holds the seals around the inner and outer cylinder.		g. Orifice.
— (7) Keeps dirt from damaging seals.		h. Follower.
— (8) Lubricates the piston.		i. Scraper ring.
— (9) Holds the orifice in place.		j. Felt wiper.
— (10) Used to mount the strut in the aircraft.		k. Lower bearing.
— (11) Maintains correct alignment.		l. Torque arms.
— (12) Used to jack strut for wheel or brake maintenance.		m. Jacking point.
— (13) Outside of the strut.		n. Axle.
— (14) Slides in and out of the outer cylinder.		o. Gland nuts.
— (15) Used to service the strut.		p. Outer cylinder.
— (16) Hold strut cap and lower bearing in place.		q. Recoil valve.
— (17) Used to prevent leakage.		r. Lower chamber.
— (18) Limits the extension stroke.		s. Seal O-ring.
— (19) Minimizes friction on the cylinder surface.		t. Strut cap.
— (20) Holds the seals, scraper ring, and felt wiper.		u. Inner cylinder.

454. Cite two differences between a main gear and nose gear shock strut, and specify the operational characteristics of a shock strut.

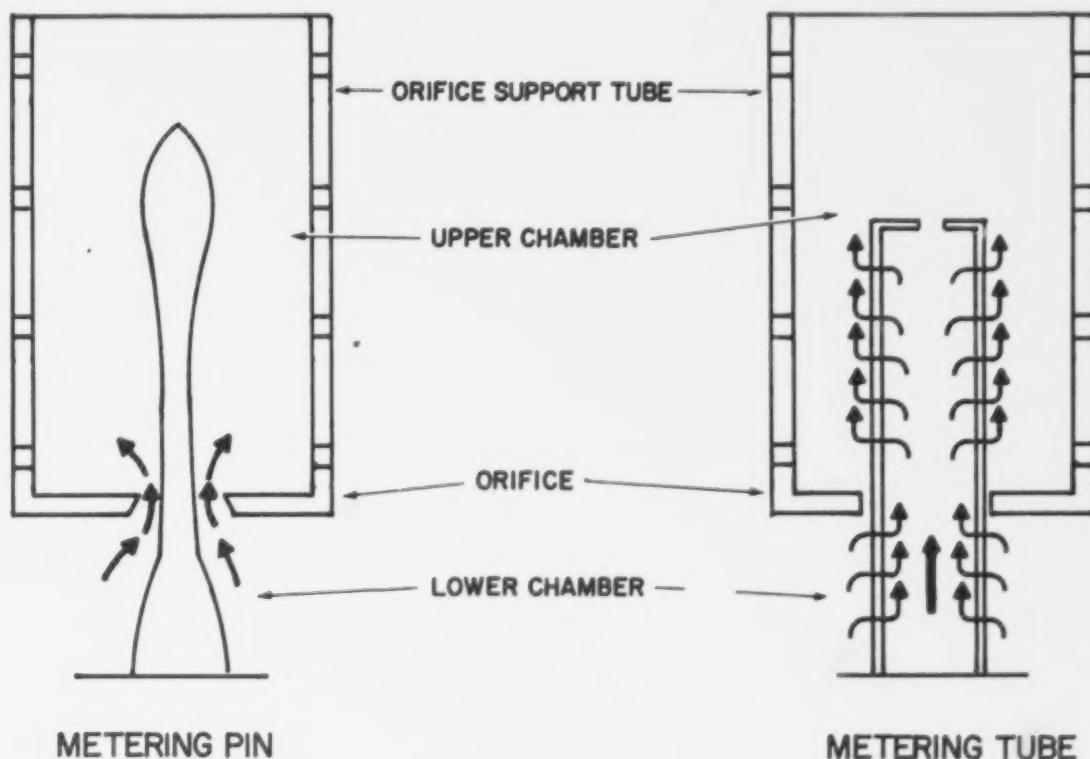
Compression Stroke. (See fig. 6-1.) During an approach for a landing, the shock strut is in the fully extended position. As the wheels strike the ground, the inner cylinder is forced up into the outer cylinder. This action will force the fluid in the lower chamber up into the upper chamber through the orifice. The metering pin is also forced through the orifice; and, by its variable shape, it controls the rate of fluid flow at all points into the upper chamber on this compression stroke. This restriction of fluid flow absorbs most of the landing impact. As the fluid is forced through the orifice, it compresses the air in the upper portion of the outer cylinder. This compressed air acts like a spring and aids in cushioning the shock strut. Notice that the recoil valve in figure 6-1 is open during the compression stroke. This allows a free flow of fluid between the inner and outer cylinders when the upper bearing is forced to move away from the extension stop.

Extension Stroke. When the force of landing decreases, the pressure of the air (nitrogen) on the hydraulic fluid forces the fluid back through the orifice and causes the inner cylinder to extend. As the inner cylinder moves down, it causes the upper bearing to move closer to the spacer (extension stop). The fluid that is between these two items must escape in order for the inner cylinder to continue to move down. This fluid flow causes the recoil valve on the inner cylinder to move up over the large fluid passages in the inner cylinder. (See exploded view in fig. 6-1.) The fluid must now pass through small holes in the recoil valve. This restriction to flow provides a snubbing action to prevent rapid rebound of the strut. The strut will slowly extend until the upper bearing contacts the extension stop. While the strut is extending, the fluid in the upper chamber has to flow through the orifice and the metering pin.

Metering Pin Operation. The metering pin moves with the lower part of the strut. The pin (see fig. 6-2) is tapered at the top and bottom. When the slender part of the pin is in the orifice, the restriction is the least. As the pin moves up or down, the thicker portion of the pin will reduce the size of the orifice. This feature prevents hard bottoming of the strut. It slows down the strut movement smoothly but firmly as it nears the end of travel in either direction.

Metering Tube Operation. In some struts a metering tube is used. (See fig. 6-2.) Notice that it has a bunch of small holes the entire length of the tube. The tube will move up or down through the orifice support tube. When the metering tube is in the middle position, the same amount of holes are in both the upper and lower chamber. This means that the flow between the upper and lower chamber would not be restricted.

Let's place the metering tube in the position shown in figure 6-2. Notice that there are more



42-1941

Figure 6-2. Metering tube and pin.

holes of the metering tube above the orifice than on the bottom. This will restrict the flow of fluid from the lower chamber because there are fewer holes for the fluid to flow through.

Nose Landing Gear. The construction and operation of the nose landing gear is basically the same as that of the main landing gear; however, the nose gear is used to steer the aircraft. (See fig. 6-3.) In order to do this, the steering collar must be positioned by a steering damper. (The steering damper will be covered in more detail later on in this chapter.) The steering collar transmits torque through the upper torque link to the lower torque link and eventually to the inner cylinder. This torque causes the inner cylinder to rotate within the outer cylinder, thus turning the aircraft in the desired direction.

Using the nose gear to steer the aircraft causes a problem. The wheel well where the nose gear fits is quite compact; and, if the nose gear is cocked off to one side or the other when it is retracted, it could damage the gear or the wheel well itself. To prevent the nose gear from being cocked to one side when the nose gear is retracted, centering cams are used to align the wheel in the straight ahead position

when the shock strut is fully extended. (See fig. 6-3.) The upper cam is attached to the upper portion of the inner cylinder. The lower cam is attached to the lower portion of the outer cylinder. When the aircraft is on the ground (fig. 6-3, A), the strut is compressed, and the cams are disengaged or separated. This allows the aircraft to be steered. Figure 6-3, B, shows that the cams have come together in the extended or engaged position.

Exercises (454):

Use figure 6-1 to assist you in describing the operation of the shock strut.

1. What position is the shock strut in when the aircraft has touched down on landing?
2. What should be used to provide snubbing and rapid rebound of the strut?

3. Which position of the orifice and metering pin will result in the least restriction of fluid flowing from the lower chamber to the upper?
4. How will the air in the upper chamber aid in the cushioning of the shock on handling?
5. What can take the place of the metering pin in some shock struts?
6. What varies the size of the orifice of the shock strut?
7. Cite two differences between a main gear and nose gear strut.
8. Why isn't it necessary to have centering cams in the main gear?
9. Why is it necessary to have centering cams in nose gear?
10. In what position are the centering cams when the aircraft is on the ground?
11. What does the torque collar do when the aircraft is being steered?

6-2. Nose Wheel Shimmy Dampers and Steering Damper Units

On an aircraft with conventional landing gear, if the pilot wants the aircraft to turn left, he has to set the left brake and rev up the engine(s) on the right side. On an aircraft with tricycle landing gear, if the pilot wants to turn left, he turns a wheel (like a steering wheel) in the cockpit which operates a nose wheel steering system that turns the nose wheel to the left. Nose wheel steering has made it much easier for the pilot to steer and taxi the aircraft. The nose wheel, however, adds an undesirable characteristic. Have you ever driven a

car that had a severe shimmy in the front end? That is the undesirable characteristic the nose wheel added to the aircraft. This shimmy adds to the possibility of nose gear structural damage or even complete failure. Obviously this condition could be dangerous and should be prevented if possible.

In this section we shall cover the components that can be found in a nose wheel steering system and the shimmy dampers used to prevent nose wheel shimmy.

455. Specify operational characteristics of the piston and vane shimmy dampers.

Shimmy Dampers. Shimmy dampers are used to prevent oscillation or shimmy during landing, takeoff, and taxiing. At the same time, they permit the wheel assembly to turn or "track" as the aircraft turns when taxiing. By "tracking" ability, we mean the ability of the nose wheel to turn in the same direction the aircraft is pointing.

Nose wheel dampers are either the vane type or piston type, both of which use an orifice to restrict fluid flow from one chamber to another. This will allow a small amount of fluid to pass through during slow movement of the nose wheel, but will offer a high resistance to a large amount of fluid caused by a sudden movement, or shimmy, of the nose wheel. Although shimmy dampers are rarely used by themselves, they are found in other units which will be discussed later on in this chapter. This section will give you a good understanding the construction and operation of shimmy dampers.

Piston shimmy damper. The balanced piston shimmy damper (see fig. 6-4) works on the principle of equal forces acting on either side of a piston. Both sides of the piston have equal areas because the piston rod runs through the piston. The unit is not part of the main hydraulic system; instead, it has its own reservoir (B). The damper is stationary with respect to the upper cylinder of the nose strut assembly; but the left end of the piston and rod assembly (D) is connected to the rotating part. This assembly is connected, through linkage, to the section of the landing gear strut that turns with the wheel. When the wheel turns in either direction, the piston and rod assembly (D) also moves. Notice in figure 6-4 that passageways connect the reservoir (B) to the chambers on both sides of the piston. Each passageway has an orifice check valve (A and C). They are placed so that free flow of fluid is always toward the cylinder chambers; restricted flow of fluid is from the cylinder chambers to the reservoir. Therefore, when the piston moves to the left, fluid flows freely from the reservoir to the right hand chamber. At the same time, fluid in the left chamber must return to the reservoir through an orifice (C). When the piston moves to the right, an opposite free and restricted flow takes effect. Rapid

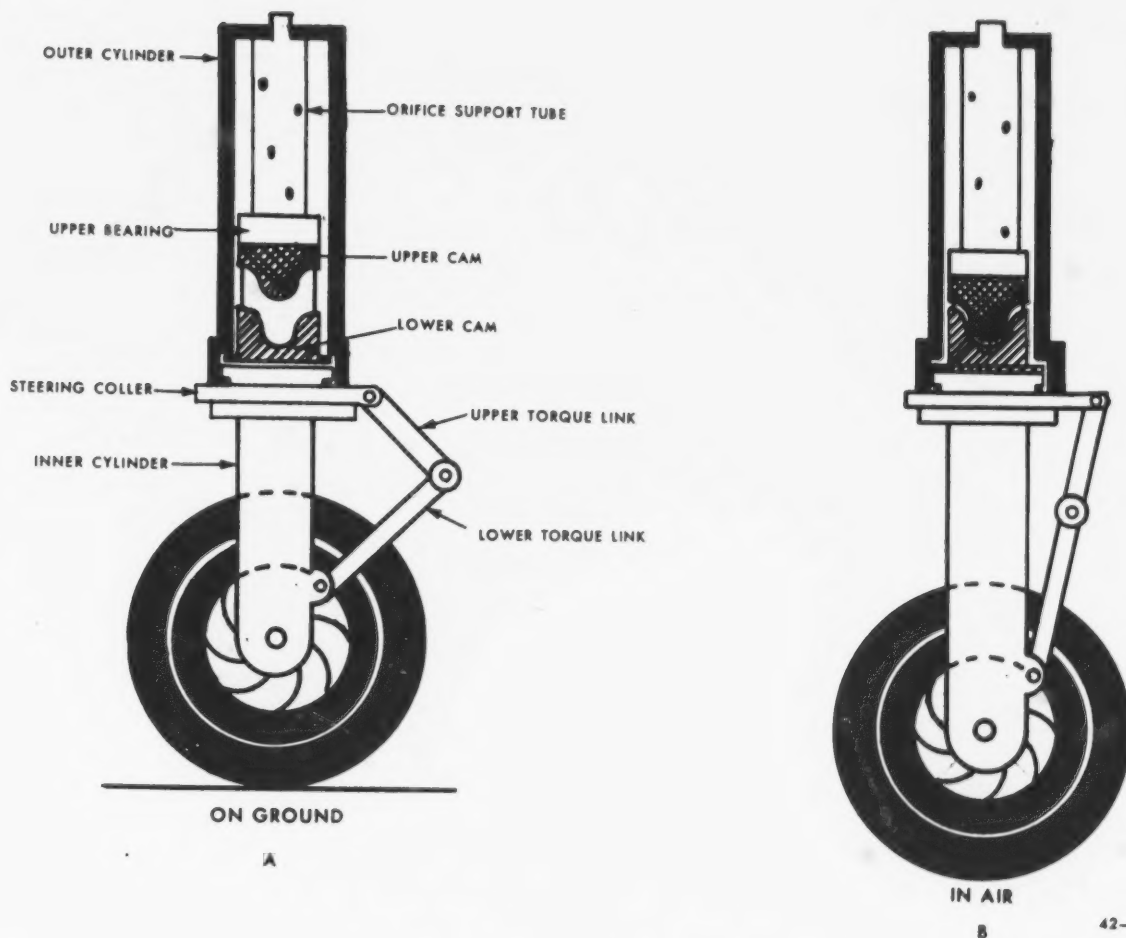


Figure 6-3. Nose gear centering cams.

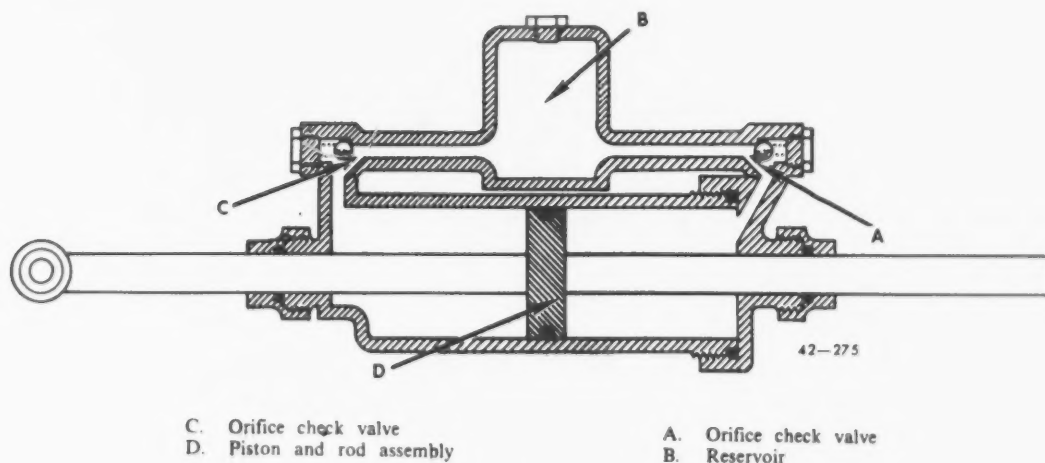
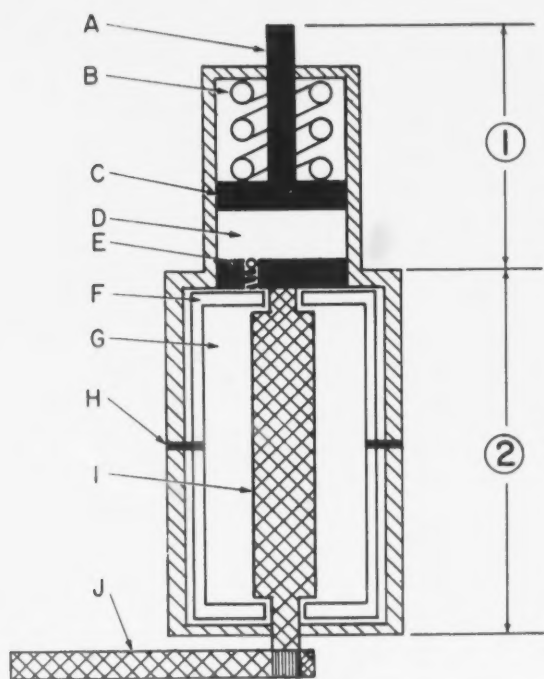


Figure 6-4. Balanced piston shimmy damper.



42-1934

- | | |
|-----------------------------|---------------------|
| A. Indicator rod | F. Stationary vanes |
| B. Spring | G. Working chambers |
| C. Replenishing piston | H. Flange key |
| D. Reservoir | I. Wing shaft |
| E. Replenishing check valve | J. Lever |

Figure 6-5. Vane shimmy damper (side view).

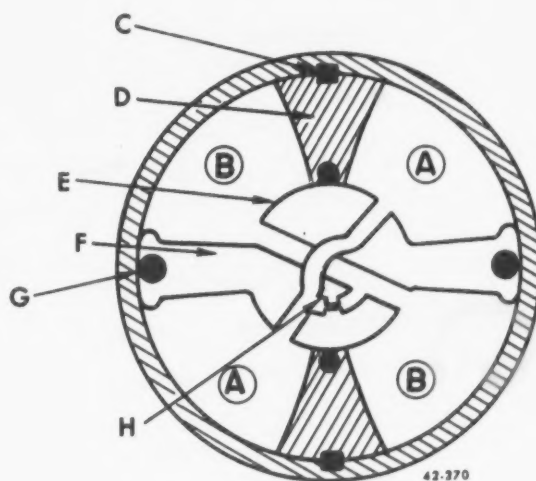
movement of the piston caused by wheel shimmy is retarded because the fluid must flow through one of the orifices. You might be wondering why we install orifice check valves instead of just orifices. It is to provide free flow into the cylinder, but restricted flow out. This arrangement prevents a partial vacuum from forming when the piston is moved rapidly to the right or left. If the partial vacuum is allowed to form, a spongy shimmy action will result. This unit is serviced with hydraulic fluid through a reservoir filler cap.

Vane shimmy dampers. Figure 6-5 shows a cutaway side view of the vane shimmy damper. Notice that it is has two sections, the reservoir section (1) and the working chamber section (2). The wingshaft (I) shows splines by which the lever (J) is attached to the collar of the strut. The flange key (H) holds the stationary vanes (F) rigid to the outer case. Fluid is pumped into the reservoir (D) through a filler fitting, which is not shown. The spring (B) forces down on the replenishing piston (C), holding the reservoir under pressure. An

indicator rod (A) is attached to the replenishing piston; it shows how full the reservoir is. The replenishing check valve (E) permits fluid to be forced from the reservoir (D) into the working chambers (G) whenever fluid is lost.

Figure 6-6 shows the top view of the working chambers of the vane shimmy damper. The fixed vanes (D) and the moveable vanes (F) divide the working chamber into four sections (2 A's and 2 B's). Fluid completely fills all sections of the working chamber.

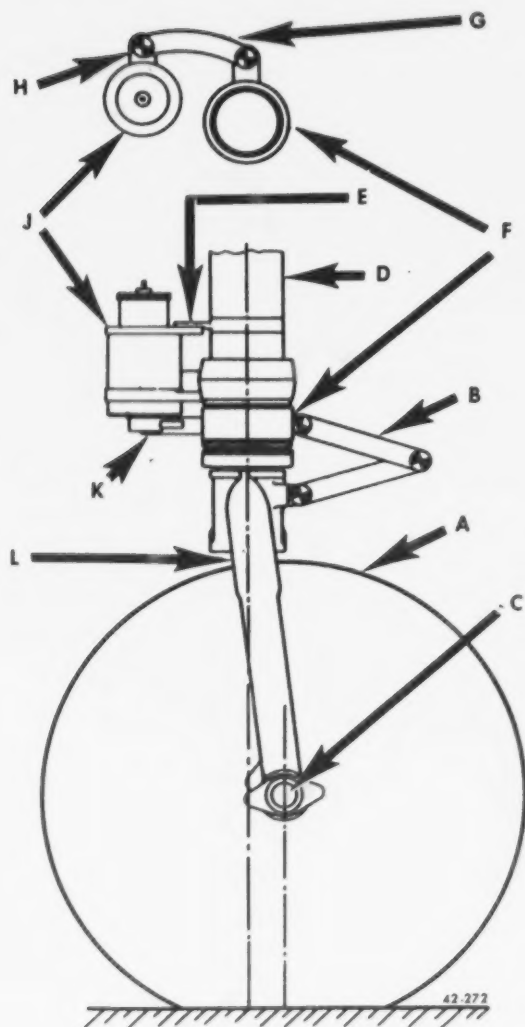
Notice that both A chambers and both B chambers are interconnected by channels. These two channels are connected to each other through a small orifice (H). Now, how does this thing work? Assume that the movable vanes (F) are being turned clockwise. Both B chamber will decrease in capacity, and both A chambers will increase. This forces fluid from the B chambers into the A chambers through the orifice (H). The orifice restricts this flow, thereby damping or slowing the movement of the wheel and preventing shimmy. When the wheel tries to turn counterclockwise, the action is the same except that now the capacity of both A chambers decreases and the capacity of both B chambers increases. Again fluid is forced through the orifice, but in the opposite direction. Again, resistance develops. Flange keys (C) prevent the stationary vanes from rotating within the housing. Hydraulic seals (G) prevent leakage between the chambers.



42-370

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|---------------------|--------------------|
| A. Chamber | E. Wingshaft |
| B. Chamber | F. Moveable vanes |
| C. Flange keys | G. Hydraulic seals |
| D. Stationary vanes | H. Orifice |

Figure 6-6. Vane shimmy damper (top view).



- | | |
|---------------------|--------------------|
| A. Wheel | G. Connecting link |
| B. Torque scissors | H. Connecting link |
| C. Strut axle | J. Shimmy damper |
| D. Nose gear strut | K. Wingshaft |
| E. Mounting bracket | L. Wheel fork |
| F. Collar | |

Figure 6-7. Mounting of shimmy damper.

The method of mounting a shimmy damper varies with the design of the nose gear. Figure 6-7 shows how a vane shimmy damper can be mounted to an aircraft strut. The damper (J) is attached to a mounting bracket (E), which is stationary with respect to the strut (D). When the wheel (A), which is attached to the strut axle (C), is turned in either direction, the fork (L), torque scissors (B), collar (F), lever and connecting links (H and G), and

wingshaft (K) all rotate or turn. When the wingshaft rotates, the shimmy damper operates as described earlier in this section.

Exercises (455):

1. Which shimmy damper has the working chambers separated by a piston?

Use figure 6-4 to answer questions 2, 3, and 4.

2. When the piston is moving to the right slowly, in what position is the check valve (C)?
3. In what position is the check valve (C) if the piston is rapidly moved to the right?
4. How is fluid added to the piston type shimmy damper?

Use figure 6-5 to answer questions 5, 6, and 7.

5. What are the two sections of a vane shimmy damper?
6. What pressurizes the reservoir of the vane shimmy damper?

7. How is fluid forced from the reservoir to the working chambers?

Use figure 6-6 to answer questions 8 and 9.

8. How are the four sections of the working chambers interconnected?
9. If chamber B decreased in size, how would the fluid from chamber B be routed to the chamber that increased in size?

456. Specify the operational characteristics of steer dampers.

Steer Damper Unit. The age of gunning an engine to turn the aircraft has long passed. Nose wheel steering is now commonly used on all aircraft. This provides ease of handling and greater directional control during taxiing, takeoff, and landing. Many manufactures have combined the shimmy damper and steering units together; they call the result a steer damper. There are two basic types of steer dampers presently in use: the single-piston type and the vane type.

Single-piston steering unit. Figure 6-8 shows a single-piston steering unit. This unit is typical of most single-piston steering units; therefore, we shall discuss its operation in detail.

Steering control of this steering-damper unit is obtained by using a slide control spool (C). The slide is positioned by a mechanical control lever and followup linkage (A). When the control lever (A) is moved, the control spool (C) is positioned to block off and open alternating ports. Notice the three ports located on the top of the control spool (C). The two ports at the bottom of the control valve connect to either side of the power piston (B). Fluid from these two passageways must first pass

through damping or orifice check valves (H). Again, they provide free flow toward the power piston cylinder and restricted flow out. The two outer ports at the top of the control valve are connected to the return outlet; the center port is connected to the pressure inlet. A centering spring (G) holds the control valve in the neutral position whenever the steering is not being used. When the control valve is in the neutral position, the entire assembly operates as a shimmy damper. The two orifice check valves provide the snubbing action.

The power piston (B) and piston rod are fastened to the stationary part of the strut at the fixed attachment point (F). The entire housing assembly is fastened to the nose wheel assembly at the nose wheel attachment point (E).

For steering, the control spool (C) is moved to either the right or left by the control lever (A). If the valve moves to the right, the center pressure port is opened, sending fluid to the bottom left-hand port. From there it goes through the right orifice check valve and on to the right-hand cylinder chamber. The upper left-hand return port of the control valve is blocked off, but the upper right-hand return port is opened. This allows fluid from the left-hand cylinder chamber to return through the orifice of the left-hand orifice check valve and on to the reservoir. As fluid pressure

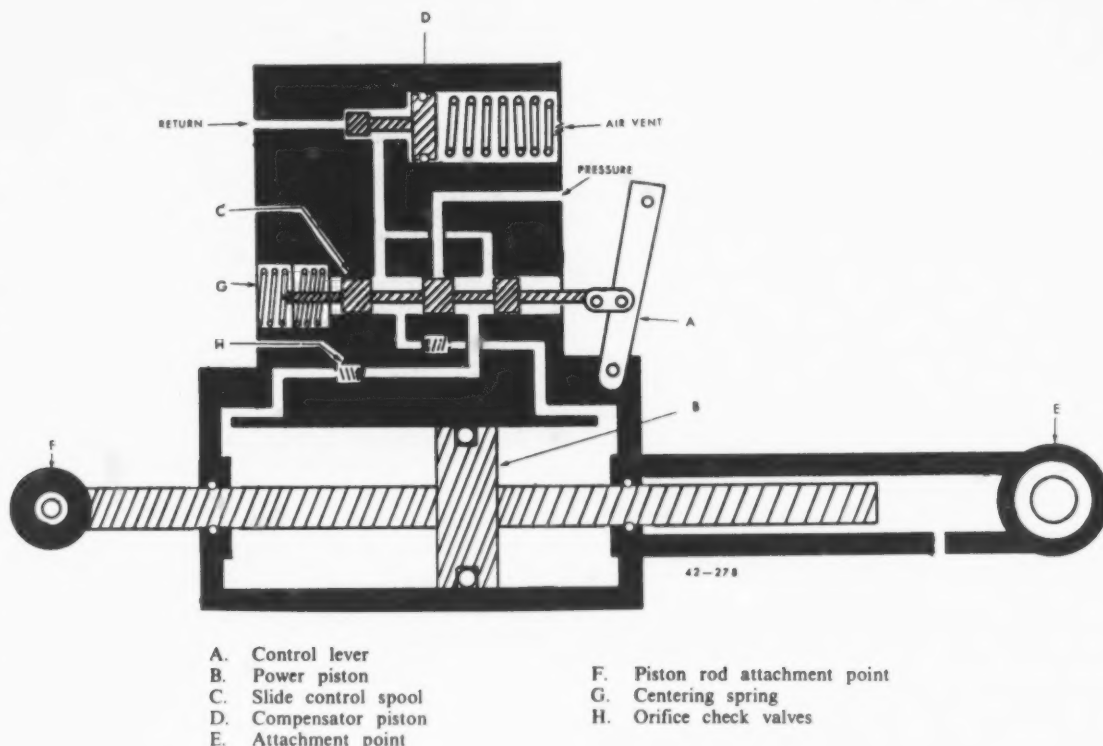
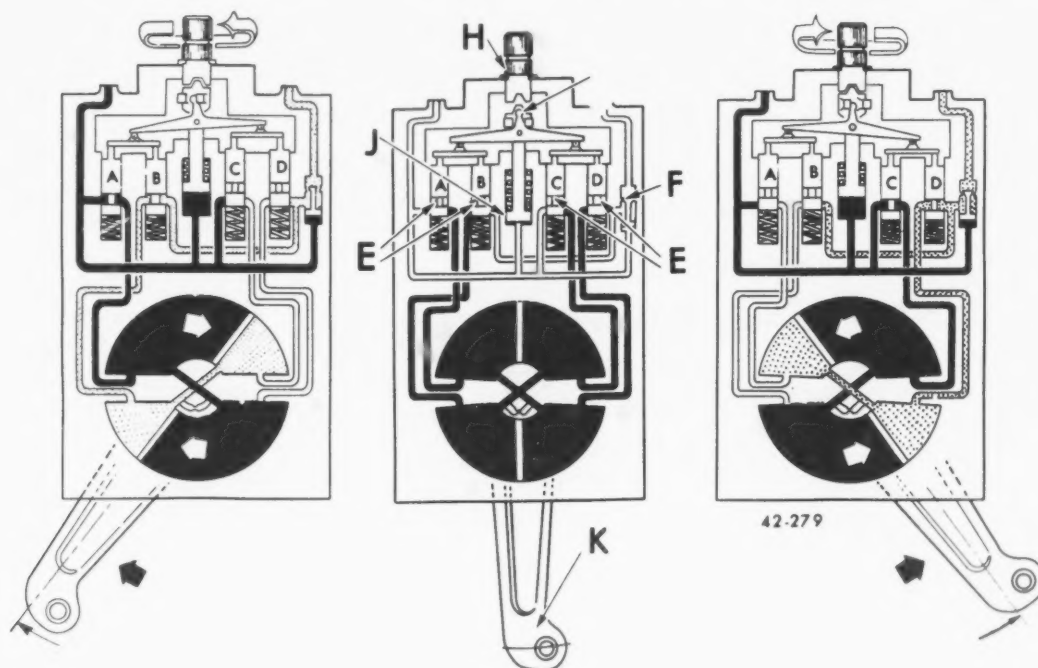


Figure 6-8. Single piston steering damper unit.

enters the right-hand cylinder chamber, the entire housing moves to the right, thereby turning the nose wheel. NOTE: The upper end of the control lever (A) does not move to the right. As the housing moves to the right, it catches up with the initial right-hand movement of the control valve. This places the control valve back into its neutral position. As long as the control valve is kept ahead of the movement of the housing, the nose gear will keep turning—that is, until it reaches its maximum pressure prevents partial vacuum in a steering actuating cylinder if the nose wheel is suddenly turned by outside forces. The compensator valve consists of a small spring-loaded piston with a built-in relief valve. Besides keeping pressure within the steering actuators, the compensator valve prevents excessive pressure due to thermal expansion.

Vane steering damper unit. The vane steering damper unit (fig. 6-9) serves two functions. It act as a steering device and as a shimmy damper. When the unit is not being used for steering, it acts as an ordinary shimmy damper. As a shimmy damper, it works like the vane shimmy damper described previously. For nose wheel steering, it uses a control valve which directs fluid pressure from the

normal hydraulic system to the working chambers. There are four control poppets (E) in the control mechanism. They are pressure and return poppets A and B for right-hand turns, and pressure and return poppets C and D for left-hand turns. The middle view in figure 6-9 shows the neutral position. In this position all ports from the poppets to the damper mechanism are blocked off. During the steering operation, pressure enters the unit through the upper left port. (Later in this course, you will learn where this pressure comes from.) It is routed to the right-turn pressure poppet (A) and to the left-turn pressure poppet (C). It is also routed to the steering engaging valve (J) and to the fluid return valve (F). Pressure forces the steering engaging valve up. This causes the steering control rocker arm and cam (G) to rise and engage the control shaft (H). A steering lever operated by the pilot rotates the control shaft in either direction. For right turns (fig. 6-9, left view), the control shaft and cam arrangement cause the rocker arm to force the right-turn poppet valves (A and B) down. This allows pressure to pass through the right-turn pressure poppet (A) to the right-turn chambers of the damper assembly. Also, fluid from the opposite chambers can pass through the right-turn return



- A. Right-turn pressure poppet
- B. Right-turn return poppet
- C. Left-turn pressure poppet
- D. Left-turn return poppet
- E. Control poppets

- F. Return valve
- G. Rocker arm and cam
- H. Control shaft
- J. Steering engaging valve
- K. Steering arm

Figure 6-9. Operation of vane steering damper unit.

poppet (B) back to the return line. The initial application of pressure to the unit opens up the return valve (F). Opening this valve allows unrestricted flow of return fluid. The steering lever (K) is attached to the nose wheel, and it causes the wheel to turn to the right. If the control shaft is rotated for left turns, the left-turn pressure and return poppets (C and D) are pushed down. This opens up the pressure and return lines to the opposite chambers of the damper. Now it will turn the steering arm and nose wheel to the left (fig. 6-9, right view). A follow-up system must be added to make it easier to steer the aircraft. It keeps the nose wheel from going all the way to the right or left when the steering is actuated. Too, it matches the movement of the steering lever (K) to the degree of turn the pilot feeds into the system. How this is done will be explained later in this course when you study the complete system. Study the center view; it will help you to figure out the steering damper operation.

Exercises (456):

Use figure 6-8 to answer questions 1 through 4.

1. What holds the control valve in the neutral position whenever steering is not being used?
2. Into what cylinder chamber will fluid flow when the control valve is moved to the left?
3. In what direction will the entire housing move if fluid pressure is increased in the left-hand cylinder chamber?
4. What unit maintains a small pressure in the steering actuator when the control valve is in neutral?

Use figure 6-9 to answer exercises 5 through 7.

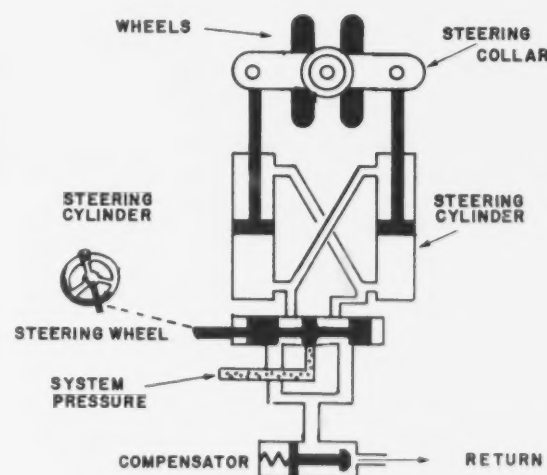
5. What poppets will be open when a left turn is made?
6. What unit will raise the steering control rocker arm and cam, causing it to engage the control shaft?

7. What function does the steer damper serve when poppets A, B, C, and D are in the neutral position?

457. Indicate whether given statements correctly reflect steering metering valve construction and operation.

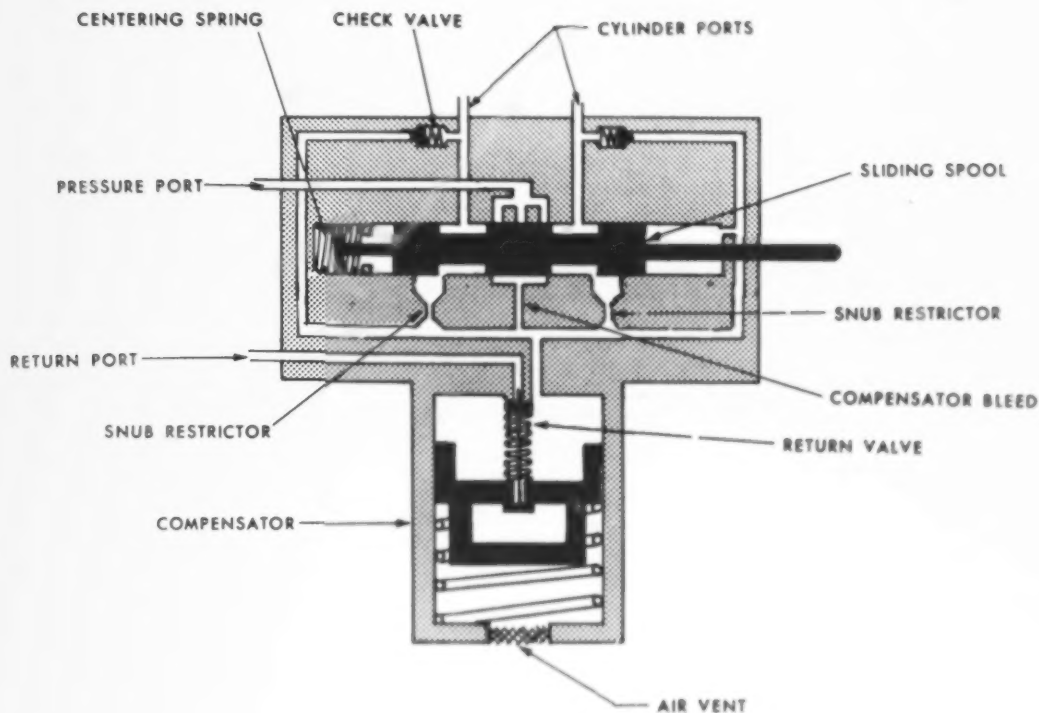
Steering Metering Control Valve. Another way of steering the aircraft is by a combination of several units connected together by tubing. Figure 6-10 shows a simplified schematic of a steering metering control valve which directs fluid to one or more actuating cylinders. We have already talked about actuating cylinders, so we will limit our discussion to the steering metering valve.

Construction of the steering metering valve. Refer to figure 6-11. The housing has four ports—pressure port, return port, and two cylinder ports. The sliding spool is positioned by mechanical inputs into the valve. The centering spring is used to insure that the sliding spool returns to the neutral position. Two anti-cavitation check valves are used to prevent air cavities from forming in the fluid. The snub restrictors are used to restrict fluid flow. The compensator is used to absorb pressure surges and maintains a constant pressure on the fluid. A continuous flow of fluid is sent to the compensator by the compensator bleed line. An air vent is placed at the bottom of the compensator to allow air to enter and exit as the compensator piston moves up and down. Now that we know the general construction of the steering metering



42-1943

Figure 6-10. Simple steering metering valve system.



42-1935

Figure 6-11. Steering metering valve.

control valve, let's talk about the different modes of operation. This valve has two modes: dampening and steering.

Damping mode of operation. When the valve is operating in the damping mode, the sliding spool is held in the neutral position by the centering springs. Fluid in the steering metering control valve is maintained at a set amount (depending on the valve) by the compensating piston and spring. In this case the pressure is set at 100 psi. When a sideways force (shimmy) is exerted on the nose wheel, the compensator piston will absorb the shock. As a shimmy occurs, it causes fluid to flow past the sliding spool, through the snub restrictors to the compensator piston chamber. Fluid flows to the opposite cylinder port from the compensator chamber through the snub restrictor and sliding spool. The rate of fluid flow through snub restrictors controls nose wheel shimmy. If pressure in the valve becomes excessive, the compensator piston would open the return valve. This action would vent excessive pressure to the system return line. In case of a violent movement (shimmy), the anti-cavitation check valves would be forced open to allow the fluid to bypass the snub-restrictors and flow directly from the compensator chamber to the cylinder port requiring the additional fluid. Without

the anti-cavitation check valves, the fluid could not move fast enough through the snub restrictors to prevent cavitation.

Steering mode of operation. To place the steering mode in operation, system pressure must be applied. System pressure is blocked off by the sliding spool. A small amount of fluid, however, is allowed to enter the compensator piston chamber by passing through the compensating bleed line. This replenishes the chamber with fluid. To turn the nose wheel to the right or left, the pilot uses a steering control wheel that is mechanically connected to the sliding spool. Use figure 6-10 and follow along as we describe the steering mode. When the pilot turns the steering wheel in one direction, the sliding spool is moved to the right or left. System pressure is directed to the actuators by the sliding spool. Fluid displaced on the opposite side of the steering cylinder piston is forced past the sliding spool to the compensator piston chamber. From here it forces the compensator piston to the left. When the compensator piston moves far enough, it causes the return valve to open and allow the fluid to flow into the system return line. As the steering cylinders move, the steering collar and wheels move in the desired direction. To turn the nose wheel in the opposite direction, the steering wheel is turned in the opposite direction.

Exercises (457):

Indicate whether the following statements correctly reflect the construction and operation of the steering metering valve by placing a T in the blank if it is true or an F in the blank if it is false. Correct the false statements.

- 1. Fluid in the steering metering control valve is pressurized by the compensator piston and spring during the dampening mode.
- 2. Nose wheel shimmy is controlled by the snub restrictors.
- 3. During the dampening mode, pressure surges are relieved by the action of the compensator return valve.
- 4. The metering valve sliding spool is spring-loaded to the neutral position.
- 5. Anti-cavitation check valves relieve excessive system pressure during a violent shimmy.
- 6. The sliding spool can be positioned by a steering wheel.

6-3. Brake System Components

In this section we will discuss the units in the brake system. You will learn how these units can be arranged into different types of systems; specific designing depends upon such factors as the landing gear layout and size and type of the aircraft. We will cover the operation of several typical systems and the operation of the individual units.

Aircraft brake systems are somewhat different from each other because they must meet different requirements, but they are all used to stop the aircraft after landing and during taxiing.

Even though landing gear arrangements vary, all aircraft brake systems fall into three main types: independent, integral, and slave brake systems.

458. Define an independent brake system, and specify the operation of a master cylinder.

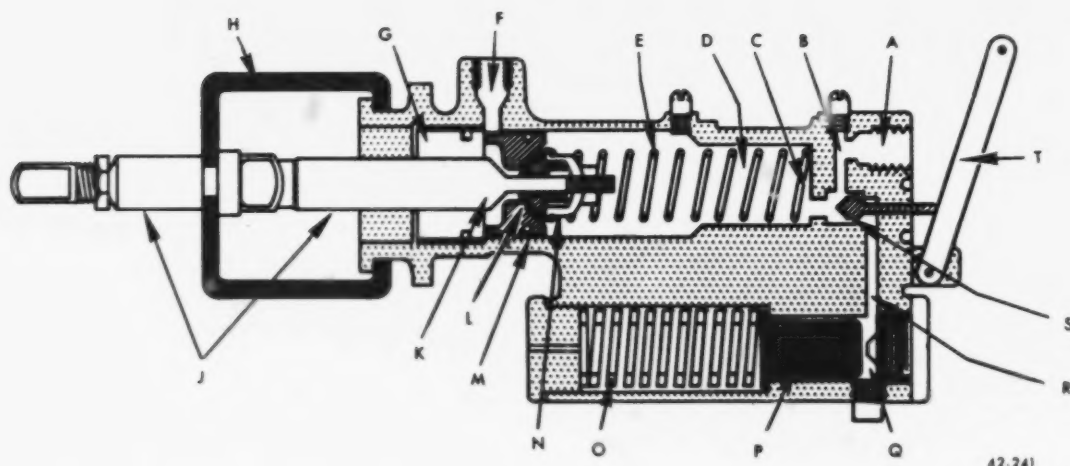
Independent Brake System. An independent brake system usually is not connected to the main hydraulic system of the aircraft. It is an independent system on its own, consisting of a reservoir, master cylinder, and brake. The reservoir was covered earlier in this volume, and the brakes will be discussed in more detail later on in this chapter, so we will talk only about the master cylinder at this time.

There are many types of master cylinders, and they vary in size and shape depending on their use. Because of their low volume output, they are mostly used with small brake assemblies. Figure 6-12 illustrates one type of master cylinder. It, like all others, converts mechanical force into hydraulic flow. The pilot's brake pedal is mechanically linked to the master cylinder piston rod (J). Whenever the brake pedal is pushed down, the piston rod moves to the right. The first movement of the rod will push the retainer of the small spring and retainer (N) away from the piston head (M). This allows the poppet (K) to seat on piston head (M). The reason for this action is to seal the piston head passage (L) before the piston head moves. This traps the fluid in the master cylinder chamber (D) when the piston head moves forward.

Now, as the piston rod continues to move to the right, it pressurizes the fluid in the master cylinder chamber (D). The fluid is forced out into the brake lines through the passageways (C and B) and the brake port (A). Figure 6-13 will help you to visualize these movements of parts and fluid. The wheel brake assemblies are thereby actuated, and the friction surfaces are brought into contact. The braking force applied to the brakes themselves is in direct proportion to the force applied on the brake pedal.

Braking stops when foot force on the pedal is released. (See fig. 6-12.) This allows the return spring (E) to force the rod and piston back to the left. Slotted fingers extend rearward from the piston head and contact the bushing (G). This action stops the leftward movement of the piston head. The piston rod will continue to move to the left until the retainer part of the piston head (N) is again seated on the piston head. This extra movement again lifts the poppet (K) from its seat on the piston head and reopens the piston head passage (L). Now, if any fluid was lost by leakage during application of the brake, it can be replaced. Fluid will be drawn from the reservoir through the reservoir port (F) into the chamber behind the piston head. From there it will pass through the piston head passage to fill the void in the master cylinder chamber (D). This route also permits return flow of fluid from the system to the reservoir if thermal expansion occurs—that is, when the brakes are not applied.

When parking an aircraft equipped with this type of master cylinder, first depress the brake pedals to



- | | |
|----------------------------|------------------------------|
| A. Brake port | L. Piston head passage |
| B. Passageway | M. Piston head |
| C. Passageway | N. Small spring and retainer |
| D. Master cylinder chamber | O. Compensating spring |
| E. Return spring | P. Compensating piston |
| F. Reservoir port | Q. Compensating chamber |
| G. Bushing | R. Compensating passage |
| H. Protective boot | S. Compensating poppet |
| J. Piston rod | T. Lever |
| K. Poppet | |

Figure 6-12. Side view of master cylinder.

pressurize the brake systems. Next, pull the parking T-handle. As this is done, the action in the master cylinder proceeds in the following manner: The lever (T) which is cabled to the T-handle moves to the left. This movement forces the compensating poppet (S) to close one of the passageways (C). Thus, the fluid is trapped under pressure in the brake line and assembly. The brake pedals can then be released. The piston head (N) and piston rod (J) will return to the BRAKE OFF position. However, the brake will remain in the applied position because the fluid in the system is trapped under pressure. In addition, this fluid pressure holds the compensating poppet (S) firmly on seat. Actually, then, the parking handle could be returned to the normal position without losing parking pressure. This is because trapped pressure holds the compensating poppet (S) on seat.

To release the brakes after the aircraft has been parked, firmly depress the brake pedals. This pressurizes the master cylinder chamber to the extent that it overcomes brakeline pressure. As a result, the compensating poppet (S) is forced off its seat. Release of the pedal will then move the piston head (N) to the left. Now fluid from the brake assembly can re-enter the cylinder chamber through the open passageway (C).

The compensating chamber (Q) and compensating piston (P) make up for thermal

expansion and fluid replenishment while the aircraft is parked. When the brakes are applied and the T-handle is pulled, the compensating poppet (S) is repositioned. It moves from its seat blocking the compensating passage (R) to a seat blocking the passageway (C). As it moves across, it will momentarily leave both seats uncovered. At that moment, fluid pressure can enter the compensating chamber (Q) through the compensating passageway (R). It will push the compensating piston (P) to the left, compressing the compensating spring (O). Thus, when the aircraft is parked, there is fluid trapped in this chamber. This arrangement of chamber, spring, and piston acts like a spring-loaded accumulator. It stores fluid under pressure to handle any decrease in brake pressure due to leakage or thermal contraction. Likewise, if thermal expansion takes place in the brake assembly, it will absorb the added volume. Thus, the compensating spring and piston maintain a balance in the brake system under varying temperatures.

Exercises (458):

1. Define an independent brake system.

2. When the brake master cylinder is being applied, what happens to the fluid in the master cylinder chamber?
3. When the brakes are released, what forces the piston to the unapplied position?
4. In order to park the brakes, what must be done?
5. Explain how the compensator makes up for thermal expansion and fluid replenishment when the brakes are in the parked position.
6. To release the brakes from the parked position, what must be done?
7. What determines the amount of force applied to the brakes?
8. When the master cylinder is in the unapplied position, how is fluid lost by leakage replenished?

459. Indicate whether given statements correctly reflect the operation of a power brake control valve.

Integral Brake Systems. Many aircraft now have some type of power brakes or power-assisted brakes. They use hydraulic pressure from the aircraft's main hydraulic system to provide most or all of the energy required to apply the brakes. These brake systems are called integral because they are integrated with the main hydraulic system. An integral brake system is quite simple. It consists of a PBCV with hydraulic lines connecting it to the main system pressure and return, and to the brake assemblies.

The power brake control valve (PBCV) is the heart of the integral brake system. To explain operating principles of brake control valves, consider the single Bendix PBCV shown in figure 6-14. Although this valve is not longer in common use, it is given as a representative sample to explain operating principles. It is a good valve for this

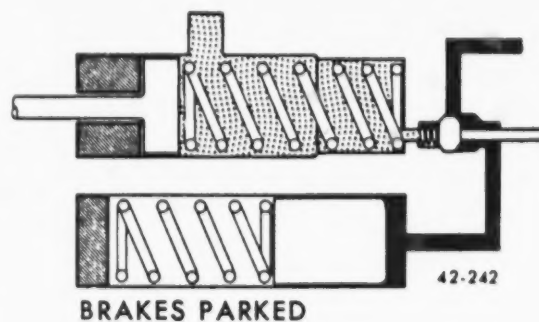
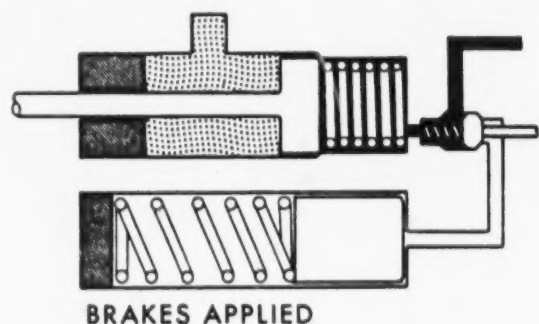
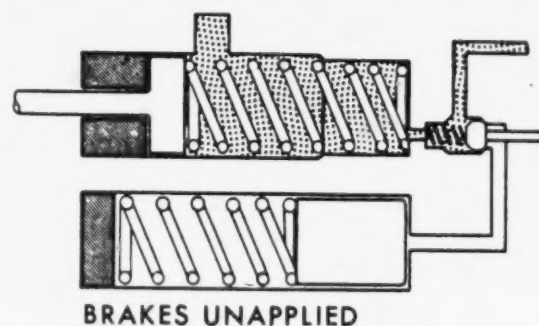
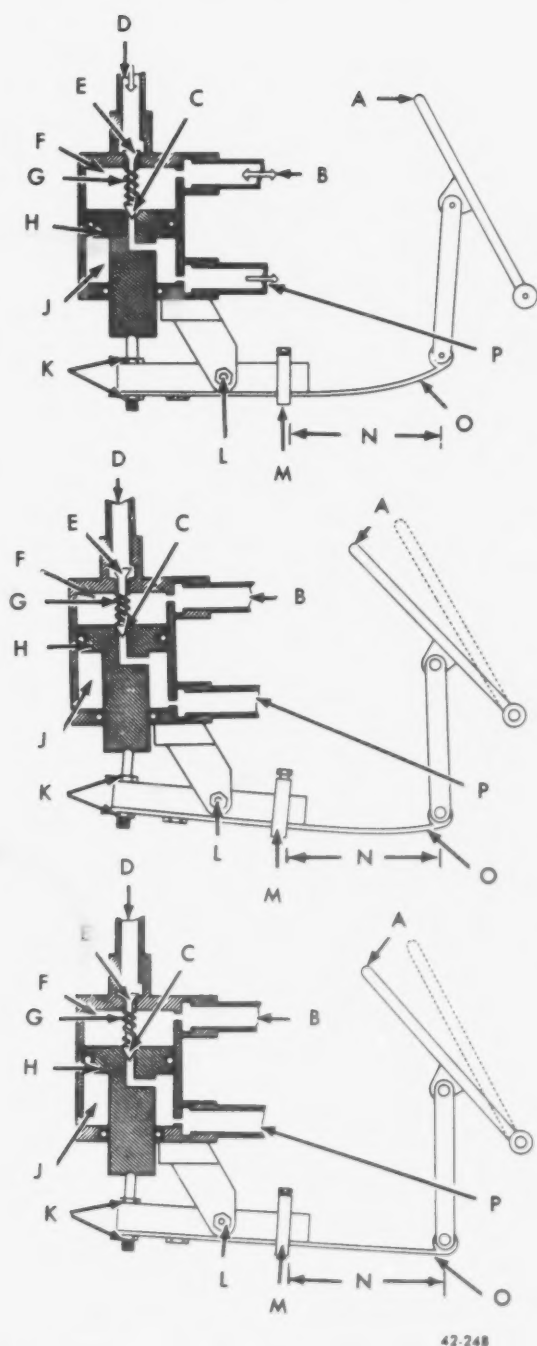


Figure 6-13. Schematic flow diagram of master cylinder.

purpose. Smaller, more complex units will be easier to understand if you are clear on this one.

In the top illustration, the valve is shown in the unapplied position. Note that lower poppet (C) is not seated on the piston. Thus, there is an open



42-248

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| A. Brake pedal | J. Lower chamber |
| B. Port to brake assembly | K. Low-pressure adjustment |
| C. Lower (return) poppet | L. Pivots |
| D. Pressure inlet port | M. Yoke (high-pressure) adjustment |
| E. Upper (pressure) poppet | N. Effective leaf spring length |
| F. Upper chamber | O. Leaf spring |
| G. Small spring | P. Return port to reservoir |
| H. Piston | |

Figure 6-14. Schematic flow diagram of PBCV.

passage between the reservoir return port (P) and the brake pressure line port (B). This provides a path for fluid replenishment and thermal expansion when the brakes are in the OFF position. Also, notice that the top picture shows the pressure port being blocked by the upper (pressure) poppet (E).

The valve begins metering fluid when the brake pedal (A) is depressed. This causes the right-hand end of the leaf spring (O) to move downward. Because the spring block pivots, the left-hand end moves upward, forcing the piston (H) against the lower poppet (C). As piston movement continues, the upper poppet (E) is unseated (middle illustration, figure 6-14). This allows fluid to enter the upper chamber (F) to the valve and flow out the brake line port (B) to the brake. As pressure increases in the brake, it also builds up in the upper chamber of the break valve. This increasing pressure creates a downward force on the piston. Since the brake pedal remains depressed, the piston will move downward when fluid force overcomes the strength of the leaf spring (O). Fluid pressure and the small spring (G) cause the lower poppet to remain seated and follow piston movement. As the movement continues, the upper poppet (E) seats again. This traps the fluid under pressure in the brake assembly, maintaining braking action. This position of the valve is shown in the lower illustration of figure 6-14. Downward force on the piston is transmitted through the linkage to the brake pedal. This force provides the pilot's foot with an opposing force that is proportional to the amount of braking pressure. Thus, the pilot has "load feel." Load feel is build into the brake system so that the pilot is aware of the amount of braking action being applied. Parking of the aircraft is generally done by holding the brake control valves in the ON position by means of a mechanical locking mechanism in the pedal linkage.

During such a period, fluid may be lost from the brake line or assembly. Such a loss will cause a pressure drop in the upper chamber of the PBCV. The leaf spring then will overcome the decreased force on the piston, forcing it and the poppet upward. This will permit more fluid to enter the brake system through the inlet port (D). This action again raises the pressure to the original level.

What happens if thermal expansion occurs while the aircraft is parked? The enlarged fluid volume will raise the fluid pressure within the upper chamber (F). The downward force on the piston will overcome leaf spring force and move the piston downward slightly. As the piston lowers, it leaves the lower poppet, thereby opening the passage through the piston. This allows fluid to escape out through the lower chamber (J) and return port (P). When enough escapes, leaf spring force again overcomes the decreasing fluid force on the piston. At that time the piston will rise and again trap the fluid in the brake system.

The pressure metered to the brakes depends upon the distance the piston moves upward; this distance is determined by the force applied to the brake pedal. A small amount of pedal pressure forces the piston upward a slight distance. Then, a relatively low pressure in the brake system can force the piston downward. It will be enough to bend the leaf spring the slight amount necessary to allow seating of the upper poppet.

A large amount of force on the brake pedal causes the piston to rise a considerable distance. In this case, a high brake system pressure is needed to force the piston downward the increased distance. It can be seen from this that the pressure metered to the brake assembly is controlled by the PBCV; this pressure is proportional to the applied pedal force. However, each system does have a certain designated maximum pressure. This pressure varies between aircraft models, but it is always enough to lock the wheels against rotation. Higher pressure is not wanted because it could burst the brake lines or rupture the seals. Therefore, an adjustment is provided on the brake control valve to limit maximum pressure output.

The maximum pressure delivered by the Bendix PBCV is controlled by leaf spring tension. The yoke adjustment (fig. 6-14, M) controls the leaf spring tension. It does so by increasing or decreasing the effective spring length (N).

Besides the high-pressure adjustment, there is also a low-pressure adjustment on the PBCV. The low-pressure adjustment nuts (K) regulate the piston height when the brake pedal is released. The low-pressure adjustment insures zero pressure in the brake system when brakes are unapplied.

Exercises (459):

Indicate whether the following statements are true or false by placing a T or F in the blank space. If the statement is false state what made it false. Correct the false statements.

- 1. The integral brake system uses hydraulic pressure from the main hydraulic system.
- 2. The PBCV is considered the heart of the integral brake system.
- 3. Load feel will reposition the PBCV back to the neutral position.
- 4. Thermal expansion cannot be relieved when the aircraft is in the parked position.
- 5. The amount of force applied to the brakes is proportional to the applied pedal force.
- 6. To insure that required pressure is in the system, the PBCV has a high and a low pressure adjustment.
- 7. When the PBCV is in the parked position, the valve will be repositioned out of the parked position as pressure increases in the system.

460. Indicate whether given statements correctly reflect the advantages and operation of the slave brake system.

Slave Brake System. The slave brake system is a combination of the independent and integral systems. Used on some very large aircraft, it consists of a slave metering valve (PBCV) remotely controlled by a master cylinder through a long pressure tube.

Slave brake systems on large aircraft are safer and lighter than simple power braking systems. True, the master cylinders add weight; but the lines carrying master cylinder pressure to the slave metering valve are relatively small. Therefore, these lines are much lighter than those carrying pressure from a single metering valve system. On very large aircraft, the length of tubing required to carry fluid from the cockpit to the brake assemblies is considerable, so the use of small tubing represents a definite weight reduction. Since the slave metering valves are remotely controlled, they can be close to the brake assemblies. Thus, the lines carrying system high pressure are short and do not enter the cockpit. (The absence of large high-pressure lines from the pilot's compartment decrease the fire hazard.)

Brake pedal action causes the master cylinder to pressurize fluid that is directed to the slave metering valve. The slave metering valve then meters main system fluid to the brake assembly.

Figure 6-15 shows a simple slave brake system. When the pilot pushes on the brake pedal, the master cylinder forces fluid under pressure to the slave metering valve. The slave metering valve is nothing other than a PBCV that uses hydraulic pressure instead of direct pilot foot force. The slave

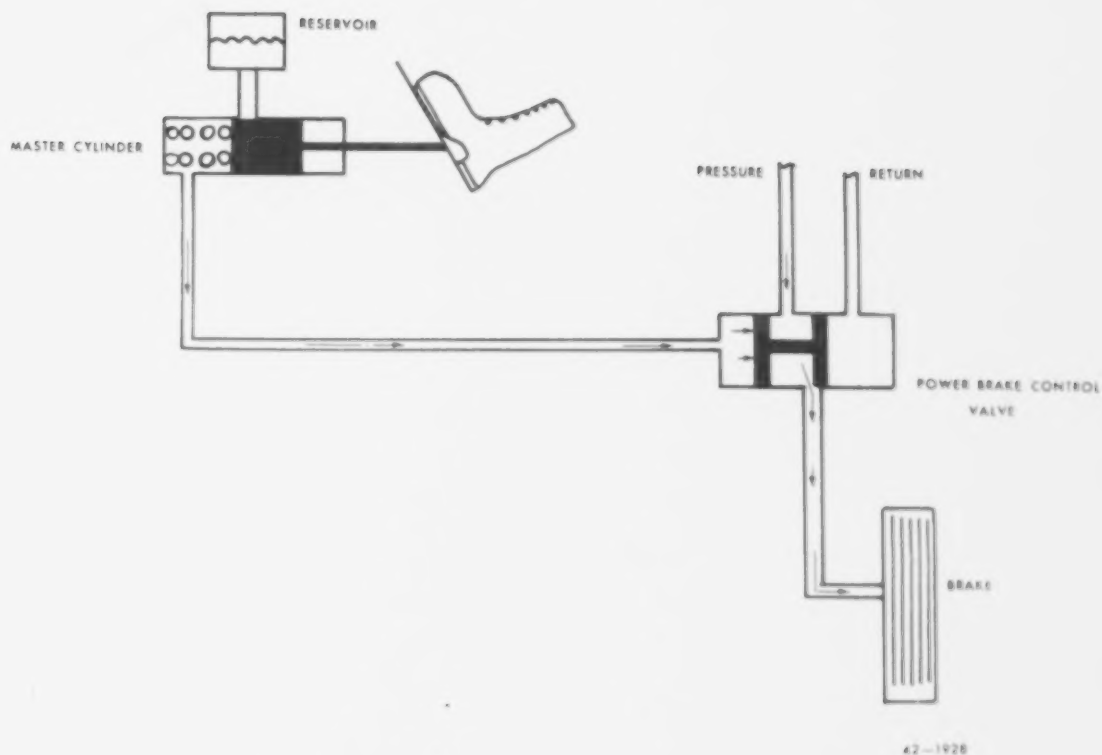


Figure 6-15. Simple slave brake system.

metering valve then meters main system pressure to the brake assembly.

Exercises (460):

Indicate whether the following statements are true or false by placing a T or F in the blank provided. Correct false statements.

- ___ 1. When a slave brake system is used on large aircraft, the use of small tubing to carry the fluid from the cockpit to the brake assembly reduces the weight of the aircraft.
- ___ 2. Since the slave metering valves are remotely controlled, they can be close to the brake assemblies.
- ___ 3. A slave brake system allows high pressure fluid lines to be kept out of the pilot's compartment.

- ___ 4. When the pilot pushes on the brake pedal, he is directly operating the slave metering valve.
- ___ 5. The slave metering valve meters fluid to the master cylinder.

461. State why it is desirable to have an antiskid control valve in the brake system, then specify the operational characteristics of the antiskid control valve.

Antiskid System. The antiskid system prevents wheel skid on the runway by automatically releasing the brake hydraulic pressure from the skidding wheel. The antiskid system consists of (1) a skid detector (some systems use an antiskid generator) mounted on each wheel and (2) an electrically operated valve in the brake pressure line to each wheel. This valve is commonly called an antiskid control valve.

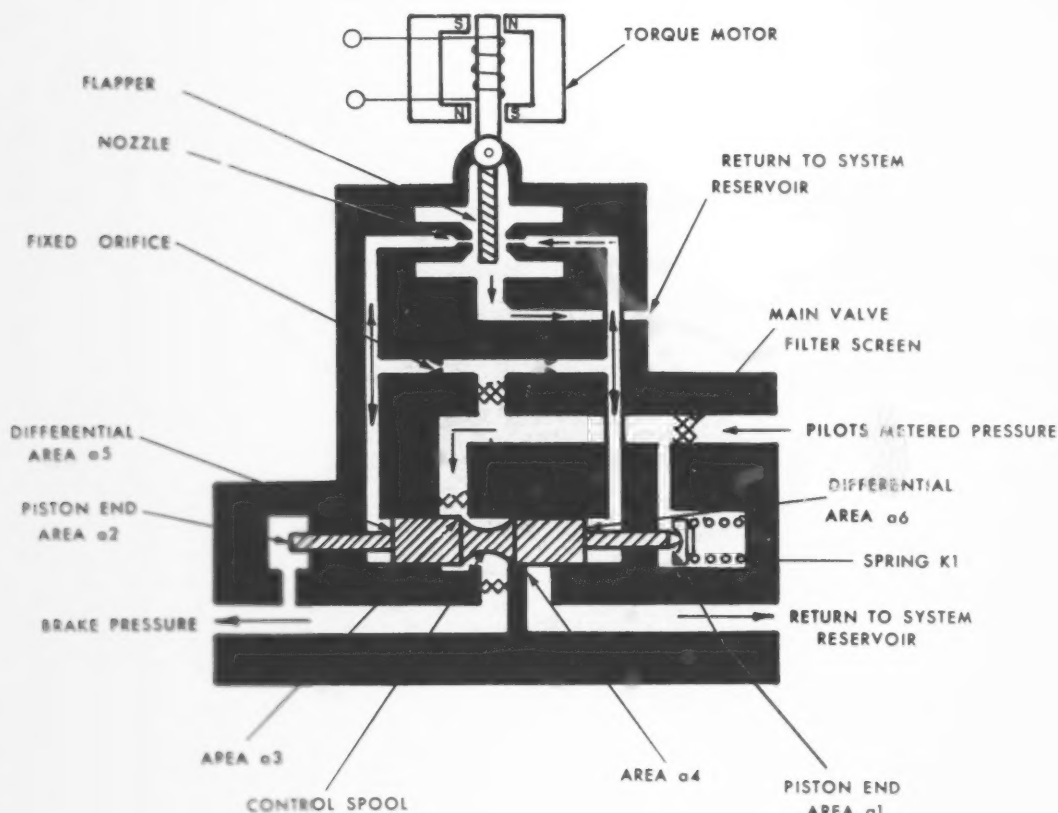


Figure 6-16. Antiskid valve.

Antiskid control valve. Figure 6-16 is a schematic of the internal flow of an antiskid control valve. This valve is similar to the flapper servo control valve which we discussed in Chapter 4. As you can see, this valve consists of a flapper-nozzle with a DC torque motor. Because the passageways through the valve are so small, filter screens are placed throughout it to catch any foreign material before it clogs one of the passageways. Notice also the control spool; the control spool is when in operation, it is perfectly balanced due to the differential pressures acting against its exposed areas. Now that you have a general idea of the antiskid valve's construction, let's see how it operates. This valve has basically two positions: manual operation (no skid) and electrical control (skid control).

No skid operation. See figure 6-16. When the pilot pushes down on his brake pedal, it meters pressure to the inlet port of the antiskid valve. Initially, with no skid signal, hydraulic pressure to the valve flows through the flapper nozzles, then out to return. Because there isn't any signal, the

pressures cannot build up any force against differential area a_6 and a_5 . The metered pressure reacts on piston end area a_1 , which, together with the spring k_1 , positions the control spool to allow metered pressure to the brakes. This is done by opening area a_3 and closing area a_4 , thus allowing fluid to be routed from the pilot's metered pressure port to the brake pressure port. As pressure in the brake pressure port builds up, it reacts against the piston end area a_2 to balance the opening force produced by the pilot's metered pressure at area a_1 . Thus, with pressure balanced, the spring acts to retain the control spool in the open position.

Skid control operation. A skid control command to the valve positions the flapper over one or the other of the nozzles. This restricts the flow of fluid past one nozzle and allows a free flow through the other. With a restriction of fluid flow, pressure can build up on the differential areas a_6 or a_5 . This unbalances the control spool and positions it to either admit more fluid to the brake or dump the pressure to return. As you can see, the antiskid control valve is designed so that any imbalance of

the pressures or areas can cause this valve to be positioned. The antiskid valve will remain in the selected position until a force balance is established by equalizing inlet pressure sensed by a_2 , nozzle upstream pressure by a_3 and a_4 , and the spring k_1 . When the force balance is obtained, the control spool is centered within area a_3 , and area a_4 is closed.

Exercises (461):

1. Why is it desirable to have an antiskid control valve in the brake system?

Refer to figure 6-6 as you answer the following question on an antiskid valve.

2. If the valve is in the manual (no skid) position, in what position is the flapper valve?
3. If a signal is sent to the torque motor and it positions the flapper valve over the right nozzle, what will happen?
4. When pressure in the brake pressure line builds up, it will push against which area?

462. State the purpose of the deboost valve; then, with reference to a given schematic, specify the deboost valve's constructional, operational, and fluid replenishing features.

Deboosters. A deboost is used in an aircraft brake system to insure rapid application and release of the brakes. The fluid pressure coming from the PBCV is high in pressure but small in volume. Most aircraft do not need such high pressure going into the brake to lock the wheels; however, large aircraft with many wheel brakes require a large volume of fluid. The deboost solves this problem. It reduces the pressure but increases the volume to the brakes.

You may be wondering why it is so important to have the brakes applied and released so rapidly, so let's examine the situation. Braking action occurs by forcing a stationary surface against a rotating surface. We also know that all brakes have an off clearance. This is the actual distance between the rotating and the stationary surfaces when the brakes are not applied. The initial volume of fluid directed into the brake unit takes up only the off clearance. The larger the brake unit, the greater the

amount of fluid required for this purpose. What happens after the stationary surface of the brake has made contact with the rotating surface? More fluid is forced in to give effective braking pressure. We must provide some means of rapidly getting a larger volume of fluid into the brake unit during application. If we don't get the fluid in quickly during application, the braking action will be too gradual. This will result in excessive heating and wear of the brakes. The cause is the extra drag on the brakes before effective braking takes place. Likewise, we must get the fluid out quickly because brakes will drag if they are released slowly. This again causes more heat and wear.

Deboosters are practical examples of force pressure-area-length-volume relationships that you learned in Volume 2. They also demonstrate mechanical advantage, or MA. Turn back and review these sections if your memory on these matters is fuzzy.

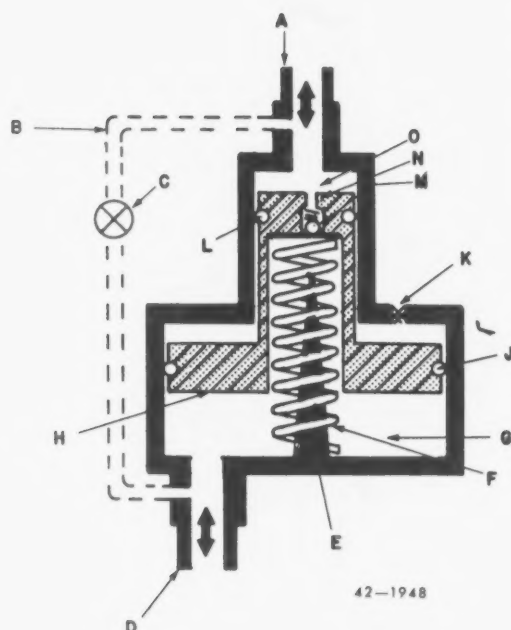
Operation. Figure 6-17 illustrates a typical deboost. A close look at it will help you to understand its operation. The main feature is the piston, which has two different areas. The upper area (N) and lower area (H) always differ in size. The size ratio of one piston area to that of the other will vary according to need. Some ratios are 3:1; that is, the lower area is three times that of the upper area. Other ratios may be 6.7:1 or 4:1, depending on the design for a specific system. For our purposes, assume that the deboost in figure 6-17 has a 3:1 ration. Pressure coming from the brake control valve enters the deboost at the metering valve port (A). It acts on the upper area of the piston. If the pressure coming in is 1200 psi and the upper area is equal to 1 square inch, the

force developed will be 1200 pounds force ($P \times A = F$; $1200 \text{ psi} \times 1 \text{ sq. in.} = 1200 \text{ lbs. force}$). With a 3:1 ratio, the lower area of the piston (H) is 3 square inches. The pressure developed on the bottom side will be 400 psi

$$\left(\frac{F}{A} = P; \frac{1200 \text{ lbs. force}}{3 \text{ sq. in.}} = 400 \text{ psi}\right)$$

This computation shows that the deboost has reduced, or deboosted, pressure.

However, this is not the most important factor. Suppose that the piston is moved down a distance of 1 inch. One cubic inch of fluid will be required to accomplish this movement. ($A \times L = V$; $1 \text{ sq. in.} \times 1 \text{ in.} = 1 \text{ cu. in.}$) At the same time, 3 cubic inches of fluid will be forced out the lower port (D). ($A = \text{of fluid will be forced out the lower port (D).}$ ($A \times L = V$; $3 \text{ sq. in.} \times 1 \text{ in.} = 3 \text{ cu. in.}$) The main purpose, that of sending a larger amount of fluid to the brake assemblies, has been achieved. The brakes are applied quickly by the larger volume under a still adequate pressure. Rapid release is obtained by



- | | |
|--------------------------|-----------------------------|
| A. Metered pressure port | H. Large piston area |
| B. External line | J. Seal |
| C. Shut-off valve | K. Air vent |
| D. To brake port | L. Seal |
| E. Opening pin (pintle) | M. Compensating check valve |
| F. Spring | N. Small piston area |
| G. Lower chamber | O. Upper chamber |

Figure 6-17. Debooster.

the reverse procedure. When the brake pedal is released, the 1 cubic inch of fluid in the upper chamber (O) is dumped back through the brake control valve. While the spring (F) moves the piston upward 1 inch, the lower chamber draws 3 cubic inches from the brakes.

The air vent (K) prevents a vacuum or high pressure condition from building up behind the piston. Two seals (J and L) prevent the fluid in the two chambers from escaping out the air vent. When the brakes are released, fluid in the upper chamber (O) returns through the brake control valve to the reservoir. The fluid in the lower chamber (G) increases in volume when the brake is released. The spring (F) creates this added volume by forcing the piston upward.

Fluid replenishment. If fluid leakage occurs anywhere below the debooster, the fluid must be replenished. In most deboosters, the replenishing is automatically done. Leakage from the lower chamber will cause the piston to ride lower in its travel. The piston can move down to a point where the opening pin (E) will contact and open the compensating check valve (M). Notice that this valve is built like a simple ball check valve. Now

compensating fluid can flow from the high side to the low pressure side of the piston. This flow will stop when enough fluid has entered the lower chamber (G) to raise the piston and close the compensating check valve (M). When the valve closes, the lost fluid in the lower chamber will have been replenished. The chamber must be large enough to hold a little more fluid than maximum wheel braking requires. This prevents the piston from normally moving down far enough to open the compensating valve. Thermal expansion of the fluid in the lower chamber can easily open the compensating valve and be relieved. With this type of debooster, no special procedure is necessary for bleeding. Whichever method of bleeding is used, the compensating valve will allow the fluid to reach the outlet.

The compensating valve and the opening pin may not be installed in some deboosters. If so, an external line (B), with a shutoff valve (C), will connect the upper and lower chambers. This shutoff valve is normally closed. Normal operation of the debooster is the same as before, but replenishing is done manually. With this arrangement, it is necessary to open the shutoff valve while the brakes are applied. This will direct pressure to both sides of the piston. Since the lower side is larger in area, the piston will be moved upward, replenishing the lower chamber. The shutoff valve need only be opened a moment, and it must be closed after replenishing is completed. Should the shutoff valve be left open, the brake unit would receive more pressure than normal. This could easily cause locked brakes and result in damage to the internal parts of the brake unit.

Exercises (462):

1. What is the purpose of the debooster valve?

Use figure 6-17 to help you answer questions 2 through 7.

2. If a debooster is rated at 3.5:1, what does this mean?
3. If a debooster has 1000 psi entering it from the PBCV, and if it is rated at 3:1, what will the pressure in the outlet port be?
4. Which two components of the debooster are primarily used for replenishing?

5. If a compensating valve and opening pin are not installed, how is the deboosters replenished?
6. What component on the deboosters prevents a vacuum or high-pressure condition from building up behind the piston?
7. What happens to the fluid in the upper chamber (0) when the brake is released?

6-4. Brake Assemblies.

In the preceding section you learned how various brake system components are used. Their purpose is to deliver hydraulic pressure to the brake assemblies in proper quantity. These brake assemblies must operate at a high degree of efficiency, and they must do so with a minimum amount of lining wear; they must also be highly resistant to the condition known as brake fade, which is a gradual loss of braking action due to overheating.

One of the basic laws of physics states that any body in motion has kinetic energy. Thus, a bullet in flight has energy, and this energy is expended when it hits an object. Likewise, a moving aircraft or automobile has energy that is expended when it stops. Therefore, the motion of any body ceases when its kinetic energy has been expended. One of the best ways to dissipate this energy is to convert it into heat. Brakes convert the kinetic energy of a moving aircraft into heat. The amount of energy contained depends upon the weight (mass) of the aircraft and its speed (velocity). Thus, the amount of heat generated to stop the aircraft depends solely upon these factors. The brakes must be of a correct size and design to handle this heat. Better brakes are designed to tolerate high temperatures and to dissipate the heat rapidly.

You have no doubt watched large aircraft rolling down the runway after landing. Did you ever think about how much heat was being generated from the braking action? It's probably a lot more than you ever thought. It is enough to raise the temperature of a seven-room house from freezing to around 70°. The friction and heat cause braking materials to wear away, warp, and deteriorate. As the pneumatic mechanic, you adjust, inspect, reline, and replace these brakes.

In this section we will cover three types of brake assemblies—the multiple disc, the segmented rotor, and the spot disc.

463. Match the components of a multiple disc brake assembly to their purposes or operations.

Multiple Disc Brake. The multiple disc brakes are used on many of the more advanced aircraft in the Air Force inventory. Although many multiple disc brakes may vary slightly in design, they all work basically the same. Figure 6-18 shows a cross-sectional illustration of a typical multiple disc brake. As shown in the illustration, the brake assembly includes a carrier (housing); the heat stack, (which is composed of the rotating discs (rotors) and stationary discs (stators); a pressure plate; and a backing plate. Inside the housing is an automatic adjuster assembly consisting of a grip tube, grip, spring guide, spring, and piston. Notice the insert that depicts the grip tube and grip. It shows a hollow tube and a doughnut-shaped grip "squeezed" onto the tube. This grip can move on the tube, but it takes a considerable force to move it. To show you how this works, take one of your fingers and wrap it around your thumb. Now squeeze your finger and at the same time try to pull your thumb away from your finger. Notice that the harder you squeeze your finger, the harder it is to remove your thumb. The grip and tube grip work basically the same way. Now that you have a general idea of the construction of the brake assembly, let's talk about its operation. When hydraulic pressure is applied to the brake, the pressure causes the piston to move inward (toward the stack of discs). The stem of the piston contacts the grip tube, forcing the grip and spring guide to compress the spring. As the grip tube continues to move, it forces the pressure pad against the pressure plate. This force squeezes the stack of discs against the backing plate and provides the braking action needed to bring the aircraft to a stop. When brake pressure drops off, the spring forces the spring guide, tube grip assembly, and piston to the right. This movement forces any fluid in the piston chamber to return to its source. The rotors on the brake are now free once again.

As the lining surfaces on the discs, pressure plate, and backing plate wear, the piston must move farther inward to give the required "squeeze." When this happens, the action of the piston moving outward will cause the grip to move on the tube. As was stated, when the fluid pressure is released, the spring will cause the grip tube assembly (and piston) to move back into the brake housing, thereby releasing the squeeze placed on the discs. But, since the grip tube assembly can move back only a small amount until it bottoms out in the other direction, the running clearance between the discs remains the same at all times.

Multiple disc brakes have one big disadvantage, the warping of the discs which takes place when they are overheated. Much of this is due to the brakes' large friction area and poor heat dissipating qualities. Long, hard application of the brakes will cause the discs to become very hot.

Maintenance of the multiple disc brakes may include bleeding, checking discs for wear, replacing

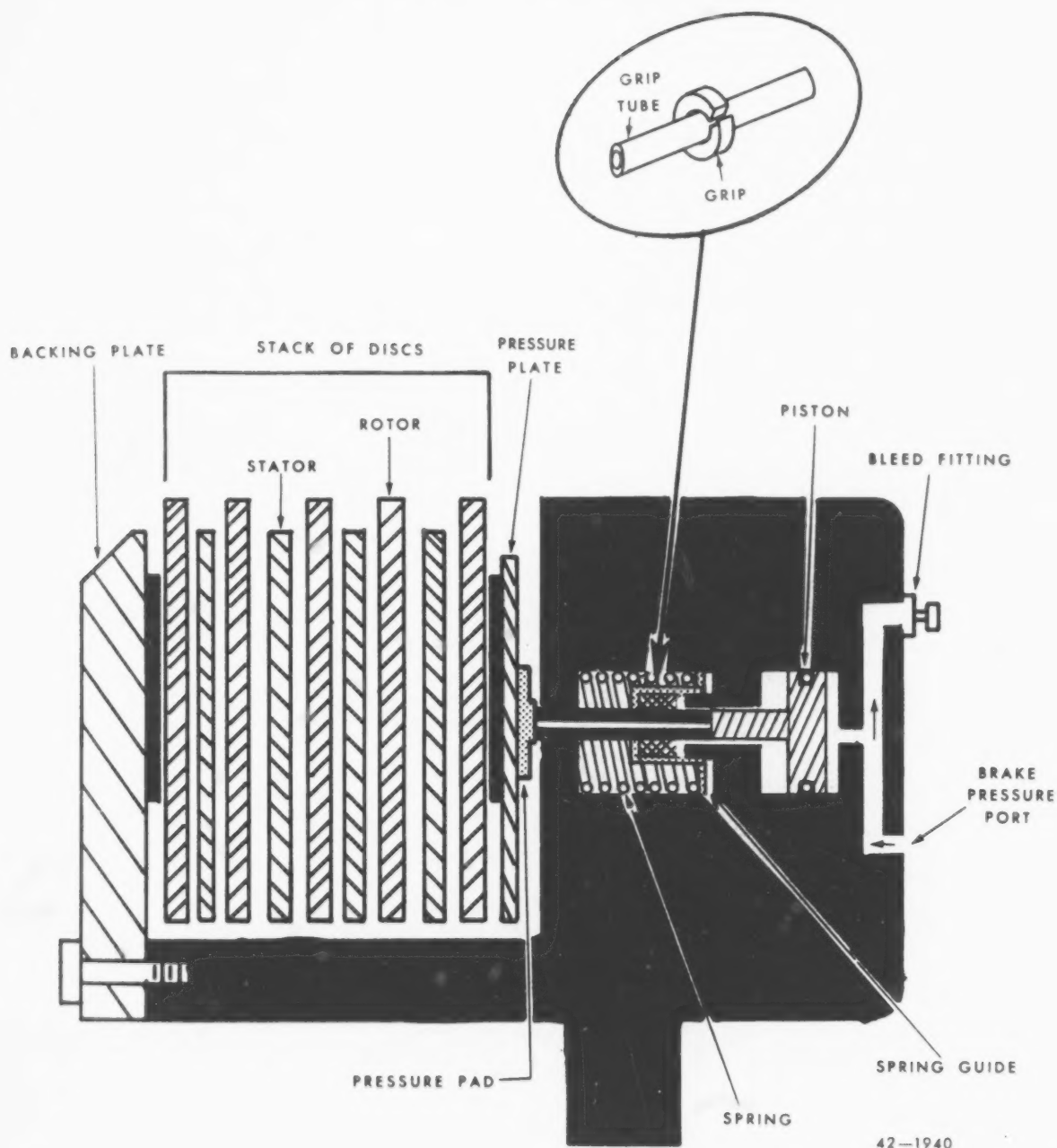


Figure 6-18. Multiple disc brake assembly.

discs, and performing operational checks. Notice the bleeder valve on the carrier, which makes it possible to bleed the brake of air. We will talk more about bleeding brakes when we get into the aircraft systems later in this course. When the discs in the heat stack show enough wear to be considered unserviceable, the entire heat stack need not be replaced. The rotors and stators may be

replaced separately. Always consult the TO for the aircraft on which you are working. In order to remove the heat stack, remove the bolts on the backing plate, and remove the backing plate. This allows you to remove the stack of discs for inspection or replacement. Note: Install the rotors and stators in the same order and positions they occupied before removal.

Exercise (463):

1. Match each of the components of the disc brake listed in column B to its purpose/operation in column A.

Column A Purpose/Operation	Column B Components
— (1) The disc that rotates with the landing gear.	a. Bleeder valve.
— (2) Automatically adjusts the brakes to maintain the correct "running clearance" between discs.	b. Carrier.
— (3) Returns the brake to the off clearance.	c. Stator.
— (4) Can be removed for inspection of the "heat stack."	d. Rotor.
— (5) Forces the stacks of discs against the backing plate.	e. Backing plate.
— (6) Pushes against the grip tube to apply the brakes.	f. Pressure plate.
— (7) Guides the spring as it compresses and expands.	g. Grip tube assembly.
— (8) Used to free the brake of air.	h. Piston.
	i. Spring.
	j. Spring guide.

464. Specify the construction and operation of segmented rotor brakes.

Segmented Rotor Brakes. The segmented rotor brake operates on the multiple disc brake principle in that it has rotating discs that are squeezed between stationary discs. Also like the multiple disc brake, the segmented rotor brake has a large amount of braking surface with a comparatively small diameter. If you remember, the discs on the multiple disc brake were subject to warping due to the extreme heat. The segmented rotor brake has segmented rotors that are linked together. (See fig. 6-19). Because they are linked together in this manner, the rotors will not warp as do the discs in the multiple disc brake. They flex when the metal expands or contracts with heat or cold.

Now that you understand why this brake is called a segmented rotor brake, let's talk a little more about its construction. Refer to figure 6-20. Notice the brake pressure port, the piston with a seal to

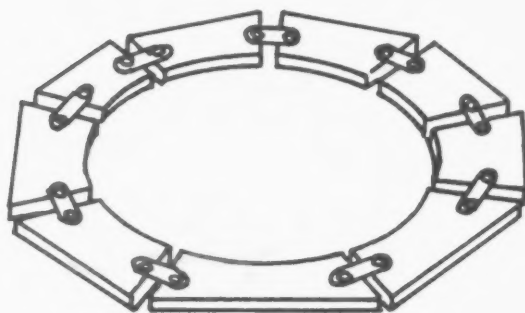
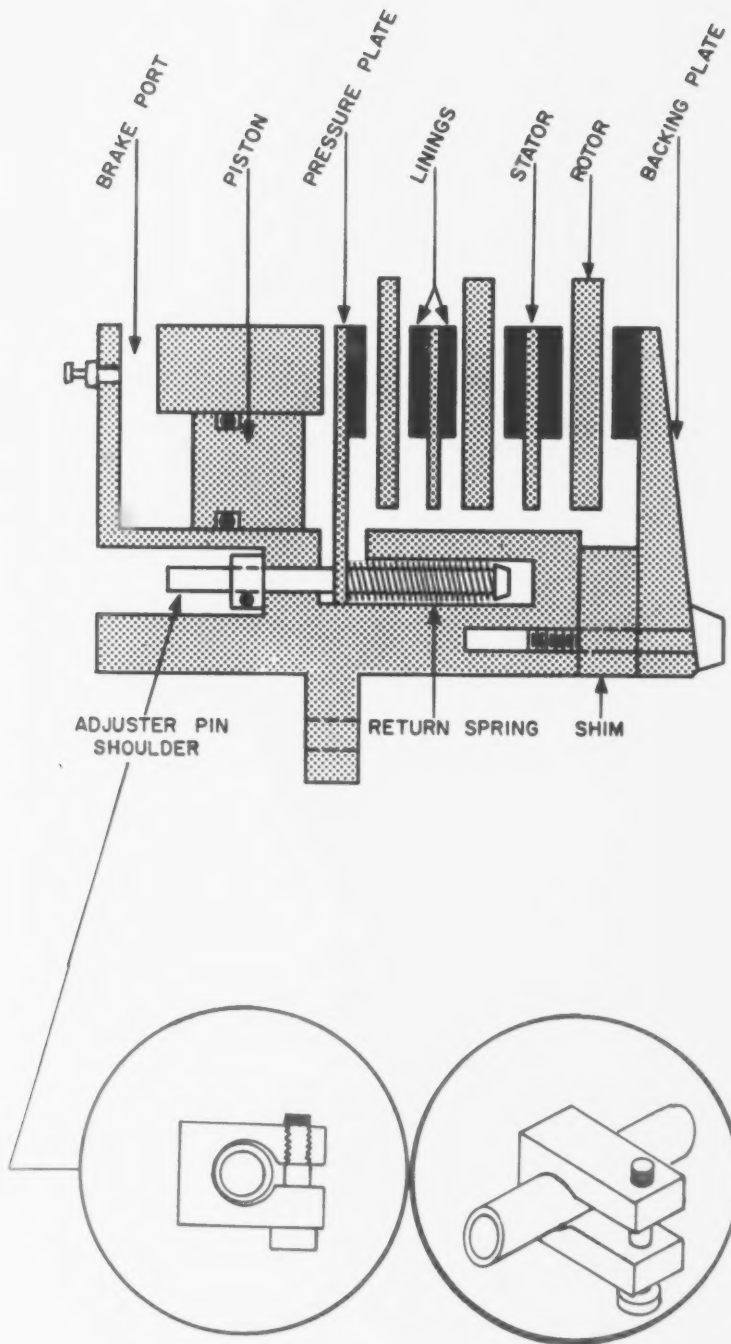


Figure 6-19. Segmented rotor.

prevent leakage, the linings that are riveted to the pressure plate, the stators, and the backing plate. These linings are the items that normally wear, and they can be replaced during overhaul. This brake is self-adjusting and has an automatic adjuster assembly, which we will talk more about later.

Now let's see how this brake operates. During brake application, fluid is directed to the left-hand side of the piston. Fluid pressure then forces the piston to the right. This causes the sandwiched stators and rotors to be squeezed between the pressure plate and the backing plate. The friction produced by this squeezing action causes rotating segmented rotors to slow down. Since they are keyed to the wheel, it also slows down. The resistance developed is directionally proportional to the amount of pressure placed behind the pistons by the fluid. Thus, as in other brakes, the braking action can be gently or severe, depending upon the pressure metered to the brake assembly. As pressure is relieved from behind the piston, the spring forces the pressure plate back. Figure 6-20 contains an insert that gives a detailed illustration of the automatic adjuster mechanism. This adjuster is designed to maintain a fixed clearance when the brake is in the unapplied (OFF) position. As the brake linings wear, the adjuster automatically compensates for this wear. It maintains a uniform OFF clearance and a constant fluid requirement per brake application. The OFF clearance is the space between the discs when the brakes are not applied. These adjuster mechanisms are located in intervals around the brake assembly. The automatic adjuster consists of an adjusting pin, adjuster clamp, and adjusting clamp screw. The adjusting clamp holds the adjusting pin firmly, much like the grip on the grip tube of the multiple disc brake. The difference here is that this clamp can be adjusted to vary the amount of force required to force the adjusting pin through the clamp. To adjust the clamp, adjust the clamp screw to the torque specified in the applicable TO. If the adjuster clamp screw is undertorqued, the adjusting pin will move too far to the right at each brake application. This will eliminate the OFF clearance and cause the brakes to drag. If the adjuster clamp is overtorqued, friction on the adjuster pin will be too great. This hindrance will cause braking friction to decrease as the linings wear. Worn linings will eventually result in the complete loss of braking action.

To see how the automatic adjuster works, let's say that the brake linings have gotten thinner due to brake application. When this happens, the piston must move the pressure plate farther to the right. The amount of force applied by the piston overcomes the friction of the adjusting clamp holding the adjusting pin. The pin is now forced to move through the adjusting clamp just far enough to make up for the loss of brake lining. Now when the brakes are released, the spring forces the pressure plate back to the left until it hits the



42-1933

Figure 6-20. Segmented rotor brake assembly.

shoulder of the adjusting pin. Because of the adjusting pins movement to the right, the pressure plate will no longer rest against the brake housing but will instead rest against the shoulder of the adjusting pin. Likewise, the piston will begin to protrude slightly from its cavity to follow the pressure plate. Since the adjusting pin moves through the adjuster clamp as the brake wears, the pressure plate range remains constant. It always backs off the same distance after each application, thus giving a uniform OFF clearance. The OFF clearance is the space between the discs when the brakes are not applied.

To check how much a segmented rotary brake has worn, manufacturers recommend measuring the exposed portion of the adjusting pin. This is much simpler than measuring each lining. Look at figure 6-20. Notice the numerous lining blocks shown in the cross section of the brake. Assume that each of the lining blocks wore down $1/16$ inch. Since there are six blocks, the total lining thickness that has worn away is $3/8$ ($6/16$) inch. This means that the adjuster pin will be $3/8$ inch further to the right. So, by measuring the amount of adjuster pin showing on the outside of the adjuster clamp, you can get the total amount of brake wear. The TO tells you how much of the pin must show. When the adjust pin has moved inward the maximum distance, it is time to relign the brake. (At one time we were allowed to remove the compensating shim from the back plate to get more wear out of the lining. This is no longer permitted.)

Maintenance of segmented rotor brakes will vary according to the type of brake you have. Complete disassembly, inspection, overhaul, and repair instructions for segmented rotor brakes are contained in the brake TO. When internal inspection or maintenance is necessary, the brake must be removed from the aircraft in accordance with the maintenance instruction TO for the aircraft. A table of dimensions and specifications in the brake TO gives information on permissible wear, cracks, distortions, running clearance, and so forth. Remember that brakes are always to be returned to service in like-new condition.

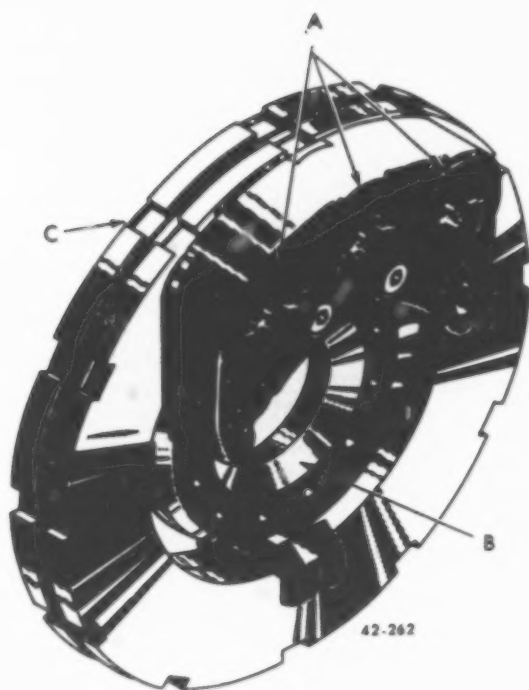
Exercises (464):

1. Why is the rotor in segments?
2. What is the purpose of having an automatic adjuster?
3. If each lining on a segmented rotor brake is worn $1/16$ inch, and if there are 8 linings, how much will the adjusting pin move in?
4. Is the segmented rotor brake assembly self-adjusting?
5. What part of the segmented rotor brake rotates with the aircraft wheel?
6. Which part of the brake forces the pressure plate against the rotor and stators?
7. If hydraulic pressure is used to apply the brakes, what returns the pressure plate to the off position when the brake pedal is released?
8. What would happen if the adjuster clamps were all too tight?
9. How would you check a segmented rotor brake to see if it is worn?
10. To what parts of the segmented rotor brake are the linings attached?

465. Specify the construction and operation of the spot disc brake.

Spot Disc Brakes. Spot disc brakes are similar in action to the multiple disc and segmented rotor brakes. A typical brake of this type is shown in figure 6-21. One or two steel discs are generally used. This depends on the type and size of the aircraft on which the brakes are installed. These discs, which are keyed or fastened to the wheel, rotate with the wheel. The brake cylinder housing contains one or more brake-actuating pistons. It is securely bolted to the torque plate of the aircraft landing gear. The piston squeezes the rotating steel discs between stationary brake linings to produce braking action. The force is applied to the flat surface of the steel disc at the spot where the actuating pistons are located. Spot disc brakes have from one to four pistons and corresponding spots. The number of pistons also depends on the type and size of the aircraft.

An outstanding feature of the spot disc brake is its rapid heat dissipation. As you can see by figure



- A. Spot
- B. Carrier
- C. Discs

Figure 6-21. Spot disc brake assembly.

6-21, there is more wheel disc area exposed to the air during application.

A schematic cross section of a single disc, hydraulically operated brake is shown in figure 6-22. This brake, like most hydraulically operated single and dual disc brakes, is self-adjusting. The illustration shows a cutaway of only one piston cavity. However, all piston assemblies of this type of brake are nearly identical. Therefore, the explanation of figure 6-22 may be applied to all of these assemblies.

Application of the single disc brake (fig. 6-22) occurs when hydraulic fluid under pressure enters the fluid pressure port (D). This fluid forces the piston (J) to the left, against spring pressure, until the spring guide (G) contacts the face of the adjusting pin (A). In moving this distance, the piston has also forced the outboard brake lining (L) against the steel disc (M). It, in turn, moves sideways on its keys and contacts the inboard brake lining (L), which is supported by the backing plate (N). Thus, the brake running clearance is taken up by this first movement of the piston. To obtain full braking friction between the rotating disc and the

lining "pucks," the piston must move further to the left. The disc must be firmly pinched between the lining "pucks." However, the spring guide (G) is already contacting the face of the adjusting pin (A). Therefore, the piston must carry the adjusting pin slightly to the left to provide this full braking action. The adjusting pin is held firmly by the friction of the adjusting pin grip (C). But pressure on the piston provides enough force to overcome this friction. This allows the piston and pin to move further to the left. If the brakes are held in the applied position, the lining wears away. The pin continues to move inward slowly to compensate for the small amount of lining wear.

What happens when brake pressure is released? The force of the brake release spring (I) against the flange of the spring guide (G) will move the piston to the right. This relieves the disc of the pinching action of the brake lining "pucks," and the wheel is free to rotate.

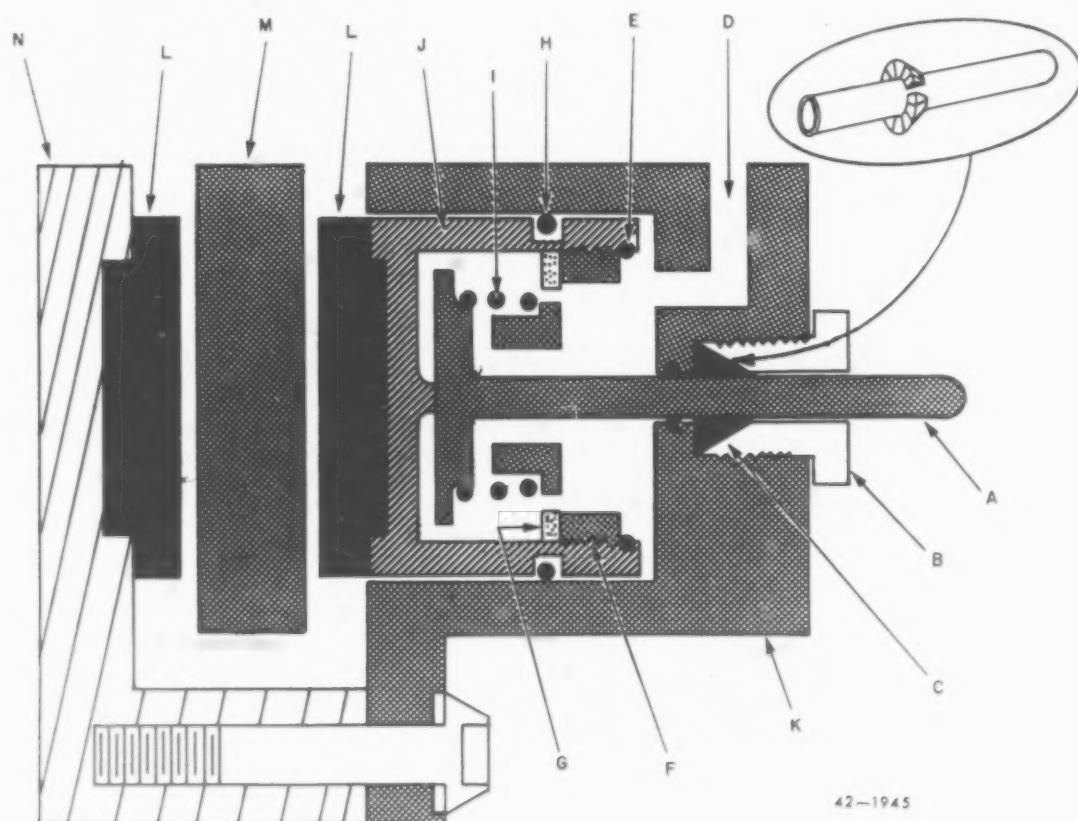
Every brake application carries the adjusting pin a little to the left to compensate for lining wear. Each time the brakes are released, the piston backs away from the outboard lining block. It can move until the back of the piston head contacts the face of the adjusting pin. Thus, the piston always releases to give the same running (OFF) clearance. The self-adjusting pin grip (C) should prevent the pin from moving to the right. See the insert in figure 6-22 for a better view of the grip on the adjusting pin.

It is very important that the self-adjusting pin nut (B) be properly torqued. If the nut is too loose, there will be insufficient friction on the pin. This will permit the adjusting pin to be drawn inward by the spring, thereby eliminating the clearance to allow the brake to drag. If the nut is too tight, friction on the pin will be too great. In this case, hydraulic pressure may not be able to move the pin inward to compensate for lining wear. This will cause braking friction to decrease as the linings wear, and it will finally result in the complete loss of brakes. Torque valves for the self-adjusting pin nuts are found in the brake TO. The threaded retaining ring (F) supports and positions the spring guide (G). The internal snap ring (E) locks in the threaded retaining ring (F). The O-ring seal (H) prevents oil leakage from the piston.

Brake linings are replaced on disc brakes when the adjusting pins have moved inward to a specified point. The pins move inward as the linings wear. Thus, the length of pin exposed shows the thickness of lining material remaining. The TO will give the distance the pins must extend to indicate sufficient lining thickness. When the pins show the minimum extension, replace the linings.

Exercises (465):

1. State the outstanding constructional feature of the spot disc brake over the multiple disc and segmented rotor brakes.
2. What returns the brake to the unapplied or off position?
3. When the "pucks" linings wear, what does the automatic adjustment do?
4. If the adjusting pin nut is under-torqued, what could happen?
5. How are spot disc brakes checked for wear?
6. To what two units is the brake lining attached?



42-1945

- | | |
|---------------------------|-------------------|
| A. Adjusting pin | H. Seal |
| B. Self-adjusting pin nut | I. Spring |
| C. Pin grip | J. Piston |
| D. Fluid pressure port | K. Brake housing |
| E. Snap ring | L. Lining (pucks) |
| F. Retaining ring | M. Steel disc |
| G. Spring guide | N. Backing plate |

Figure 6-22. Spot disc brake assembly (side view).

Answer for Exercises

CHAPTER 1

Reference:

- 400 - 1. T.
 400 - 2. F. It is used to filter the air entering the reservoir.
 400 - 3. T.
 400 - 4. F. Usually the sight gage is plastic or glass.
 400 - 5. F. The relief valve will bypass the filter.
 400 - 6. F. The standpipe supplies fluid to the main system pumps.
- 401 - 1. Because the centrifugal pump has a gap between the housing and impeller. This allows some of the fluid to seep back into the intake port if the pressure builds up too high on the outlet port.
 401 - 2. Large, low.
 401 - 3. Fluid enters the inlet port near the center of the impeller and exits through the outlet port.
 401 - 4. To prevent fluid which is returning from the system from going directly to the suction line. Thus the fluid has time to cool before it goes out again to the system.
 401 - 5. To prevent fluid loss from the reservoir during aircraft maneuvers.
 401 - 6. The suction boost pump.
 401 - 7. The pressure switch.
 401 - 8. A check valve.
- 402 - 1. Stops the fluid from foaming at high altitudes, and insures a positive fluid supply to the pumps.
 402 - 2. Air can get into the system, and the pumps could cavitate.
 402 - 3. System pressure will push harder against the pressurization piston.
 402 - 4. Through the self-sealing filler valve.
 402 - 5. Reservoir needs to be serviced.
 402 - 6. A relief valve.
 402 - 7. The relief valve can be manually operated to bleed air from the system.
 402 - 8. A spring.
- 403 - 1. It regulates the pressure to the reservoir, acts like a relief valve, and has a differential valve to allow equalization of pressures between outside air and the air pressure inside the reservoir.
 403 - 2. The relief valve built into the regulator will open.
 403 - 3. The differential valve inside the regulator will open.
 403 - 4. Usually from the jet aircraft engines' bleed air.
 403 - 5. It traps the air pressure inside the reservoir when the aircraft engines are shut down.
 403 - 6. Depressurize the reservoir.
- 404 - 1. Piston check valve.
 404 - 2. Inlet check valve.
 404 - 3. The hand pump will become completely inoperative.
- 404 - 4. The inlet check valve is malfunctioning.
 404 - 5. At least two.
 404 - 6. Fluid flows from the large piston chamber to the smaller chamber and then out to the system.
 404 - 7. It must flow through the piston check valve into the smaller piston area.
- 405 - 1. T.
 405 - 2. T.
 405 - 3. F. The drive gear is attached to the drive shaft.
 405 - 4. T.
 405 - 5. F. The gear pump uses gears instead of vanes.
 405 - 6. T.
 405 - 7. F. The vanes are able to move.
 405 - 8. T.
 405 - 9. F. The larger the angle, the more the fluid flow.
 405 - 10. T.
 405 - 11. F. It is routed back to the supply port.
 405 - 12. F. You just simply interchange the suction and pressure lines.
- 406 - 1. T.
 406 - 2. T.
 406 - 3. F. They produce less pressure surges.
 406 - 4. T.
 406 - 5. T.
 406 - 6. T.
 406 - 7. F. The cam plate pivots in the Kellogg pump.
 406 - 8. The cam plate does not rotate in the Kellogg pump.
 406 - 9. T.
 406 - 10. F. The rate piston places the cam plate of the Kellogg pump in the full flow position.
 406 - 11. F. The spider moves the sleeves in the stratopower pump.
 406 - 12. T.
 406 - 13. T.
 406 - 14. F. The sleeves are positioned by the spider.
 406 - 15. F. The leakage past the drive shaft will be routed through the shaft seal port.

CHAPTER 2

- 407 - 1. Seat, poppet, and spring.
 407 - 2. Because it is intended only to keep the poppet against the seat.
 407 - 3. Spring tension along with pressure in the outlet side of the check valve.
 407 - 4. Ball check valve. The ball follower evenly distributes the spring tension against the ball.
 407 - 5. In the open position.
 407 - 6. In the open position.
 407 - 7. In their normal operating position for flight.
 407 - 8. It would allow pressure to get to the bomb door system, which could cause them to open or close, depending on the position of the selector valve.

- 408 - 1. Male and female.
- 408 - 2. They provide a means of quickly disconnecting a line without the loss of hydraulic fluid and without allowing air to enter the system.
- 408 - 3. The lock spring prevents the union nut from backing off due to aircraft vibrations.
- 408 - 4. The back side of the union nut should be flush with the union nut sleeve. Also, there should be a gap between the lock spring and the lock spring stop.
- 408 - 5. 1/16 of an inch.
- 408 - 6. To release the lock spring from the ratchet teeth of the union nut sleeve.
- 408 - 7. Fluid flows through the holes in both the tubular and poppet valves and out to the system.
- 408 - 8. By the female half body.
- 408 - 9. The tubular valve.
- 408 - 10. It could starve the pump of fluid.
- 409 - 1. It can be opened to let fluid flow, and it can be used to vary the amount of fluid flow by partial closing or opening of the valve.
- 409 - 2. Manual, solenoid, or motor.
- 409 - 3. Globe and needle valves.
- 409 - 4. The valve's location in the system.
- 409 - 5. Motor-operated shutoff valve.
- 409 - 6. The motor-operated shutoff valve will open.
- 409 - 7. Switches built into the shutoff valve.
- 409 - 8. The valve will be forced off seat.
- 410 - 1. a. T.
b. F. The flow is directed into the pressure system.
c. T.
d. F. In the kicked in position, the spring keeps the bypass valve on seat.
- 410 - 2. a. F. The flow is direct back to return.
b. T.
c. The check valve is on seat in the kicked out position.
d. F. When the pressure builds up, it will overcome the spring tension.
- 410 - 3. T.
- 410 - 4. F. It is called the operating range.
- 411 - 1. A thermal relief valve will probably be installed in an isolated system.
- 411 - 2. Balanced outlet relief valve.
- 411 - 3. 2000 psi.
- 411 - 4. Cracking 2875; full flow 3162; and reseal of 2588 psi.
- 421 - 1. (1) b, c, d.
(2) a.
(3) a, c.
(4) a.
(5) b.
(6) c.
- 412 - 2. A bladder or diaphragm (spherical) accumulator.
- 412 - 3. A cylinder or piston accumulator.
- 413 - 1. The compensator acts like a pressurized reservoir in this system.
- 413 - 2. To relieve excessive system pressure.
- 413 - 3. It prevents fluid from the self-displacing accumulator from entering the pump when the pump is not operating.
- 413 - 4. The pressure overcomes the initial air charge and forces the piston down.
- 413 - 5. The storage space (K).
- 413 - 6. As system pressure builds up, it forces the fluid in the storage space (K) to supply fluid under pressure to the pump.
- 413 - 7. To the actuating subsystem and to the pressure chamber of the self-displacing accumulator.
- 413 - 8. The initial air charge.
- 414 - 1. Head, element, and bowl.
- 414 - 2. The filter head.
- 414 - 3. Filter elements are rated according to the amount of dirt or contaminants they can filter out. This is called the micron rating.
- 414 - 4. Anything larger than 15 microns will not pass through the filter element.
- 414 - 5. Normal fluid flow and bypass fluid flow.
- 414 - 6. When inlet pressure is higher than the outlet pressure, a condition which is caused by the clogging of the filter element.
- 414 - 7. Some filters have a shutoff diaphragm.
- 415 - 1. When the fluid temperature rises too high.
- 415 - 2. Pressure would build up and force the fluid cooler bypass valve open. This would allow the fluid entering the inlet port to go directly to the outlet port.
- 415 - 3. If the air entering the air inlet rises too high, it will cause the thermal actuator to close the ram air valve.
- 415 - 4. It makes the fuel more volatile, which allows the fuel to burn more efficiently.
- 415 - 5. a. Fluid cooler bypass valve closed, and the fuel cooler bypass valve closed.
b. Fluid cooler bypass valve closed, and the fuel cooler bypass valve open.
c. Fluid cooler bypass valve open.
- 416 - 1. They conserve space and permit ease of unit removal and replacement.
- 416 - 2. Filter C.
- 416 - 3. Check valve No. 1.
- 416 - 4. The relief valve built into the manifold.
- 417 - 1. To produce an air flow.
- 417 - 2. The fan circulates cooling air over the air compressor to dissipate the heat.
- 417 - 3. An intercooler is nothing other than finned tubing.
- 417 - 4. Gear oil pump.
- 417 - 5. This valve directs the air flow from the compressor, depending on the pressure output of the oil pump.
- 417 - 6. The suction created on the downward stroke of the piston as the crankshaft is rotated.
- 417 - 7. When the oil pressure drops off.
- 418 - 1. The relief valve relieves excessive system pressure.
- 418 - 2. The pressure switch.
- 418 - 3. The condensation dump valve will open and purge the separator of moisture.
- 418 - 4. The check valve protects the system against pressure loss during the dumping cycle and prevents system pressure from flowing back through the separator.
- 418 - 5. The moisture inside the separator reservoir could freeze.
- 418 - 6. Flame arrestor screen, rupture disc, and housing.
- 419 - 1. It serves as a trap for moisture.
- 419 - 2. To prevent them from shattering if they should rupture.
- 419 - 3. By opening the moisture drain fitting.
- 419 - 4. Drying agent.
- 419 - 5. The chemical drier cartridge must be replaced.
- 419 - 6. The cartridge must be placed in the housing so that the arrow points in the direction of flow.

- 420 - 1. A metal pin.
- 420 - 2. The body nut, valve stem, and swivel nut.
- 420 - 3. The metal-to-metal seat between the valve stem and body nut.
- 420 - 4. If the body nut is loosened with pressure in the system or unit, it could cause the whole valve assembly to be blown off, which could easily result in serious injury to personnel and equipment.
- 420 - 5. AN servicing valves have a valve core in the valve stem, and the swivel nut is 5/8 of an inch. The MS servicing valve does not have a valve core, and the swivel nut is 3/4 of an inch.
- 420 - 6. The air servicing valve is used to service pneumatic systems and units with air or nitrogen.

CHAPTER 3

- 421 - 1. F. It is closed at one end.
- 421 - 2. T.
- 421 - 3. T.
- 422 - 1. Fluctuating pointers or high and low readings.
- 422 - 2. Substitute a known good gage for the suspected bad gage.
- 422 - 3. Bleed the system of air.
- 422 - 4. To the sector gear.
- 422 - 5. The wall thickness and stiffness of the bourdon tube.
- 423 - 1. (1) f.
(2) b.
(3) c.
(4) c.
(5) g.
(6) d.
- 424 - 1. Snubbers prevent pressure surges from getting to the gage at full force.
- 424 - 2. It is installed in the line to the gage or transmitter.
- 424 - 3. Many pressure gages have orifices built into the pressure port.
- 424 - 4. It keeps the opening clean and at a uniform size.
- 425 - 1. (1) f.
(2) e.
(3) a, b.
(4) c.
- 426 - 1. The main electrical unit of the position transmitter is a circular resistance winding with three taps spaced 120° apart.
- 426 - 2. Voltages vary with the position of the transmitter wipers, causing current to flow in the indicator coils. This current creates a magnetic field within the indicator movement. The permanent magnet rotor aligns with the magnetic field of the coils.
- 426 - 3. Since tap 2 is located approximately one-third of the distance between the power contact arm and the ground contact arm, approximately one-third of the applied voltage will be dropped; in this case, 9 volts.
- 426 - 4. To the direction of coil 1.
- 427 - 1. The spring dampens the movement of the vane and returns the vane to the NO FLOW position when the fuel flow stops.
- 427 - 2. Magnetic coupling.
- 427 - 3. Flow exceeds the flow limits of the transmitter.
- 427 - 4. This indicator is calibrated in pounds per hour instead of psi.

- 428 - 1. The wiper will move down.
- 428 - 2. The pointer will be positioned to the mid point of the indicator (somewhere right around 3 gallons).
- 428 - 3. Coil B.
- 429 - 1. Generally speaking, a transducer is any device which changes one type of signal to another.
- 429 - 2. Difference.
- 429 - 3. Diaphragm.
- 429 - 4. Transducer and indicator (warning light).
- 429 - 5. Electrical.
- 430 - 1. They can be used to maintain pressure within set limits and as warning devices.
- 430 - 2. It is usually made of thin copper folded in an accordion shape.
- 430 - 3. It pushes the contacts off seat and forces the piston up.
- 430 - 4. An O-ring seal.
- 430 - 5. T.
- 430 - 6. F. It will be open.
- 430 - 7. T.
- 430 - 8. T.
- 430 - 9. F. The alternate system pump pressure switch (M) is used to complete the circuit for turning the alternate pump on and off.
- 431 - 1. It expands.
- 431 - 2. Because aluminum expands faster than copper.
- 431 - 3. The outer tube.
- 431 - 4. They are used as warning devices.

CHAPTER 4

- 432 - 1. Slide selector valve.
- 432 - 2. All the poppets will be on seat.
- 432 - 3. One pressure poppet and one return poppet will be forced off seat.
- 432 - 4. Slide selector valve.
- 433 - 1. No. Pressure cannot flow to the alternating ports when the slide control valve is in the deenergized position, but fluid can flow to return.
- 433 - 2. Centering springs.
- 433 - 3. To the right.
- 433 - 4. Solenoids permit us to position selector valves that are remotely located in the aircraft. They also reduce weight and eliminate high pressure lines from the cockpit.
- 433 - 5. Number 2 solenoid poppet is on the pressure seat, and number 1 solenoid is on the return seat.
- 434 - 1. When the pressure and return ports are blocked off by the control spool.
- 434 - 2. It will allow the fluid in the alternating ports a free passage back to return. This is desirable because pressure cannot build up in the alternating lines.
- 434 - 3. One alternating port has free passage to return, and the other is blocked off.
- 434 - 4. No.
- 434 - 5. Non-trail.
- 434 - 6. Full-trail, half-trail, and non-trail positions are achieved only when the valve is nonenergized.
- 435 - 1. To the left.
- 435 - 2. To the right.
- 435 - 3. Neutral position.
- 436 - 1. The servovalve controls the flow of fluid through the valve, which the selector valve does note.
- 436 - 2. Left cylinder port.

- 436 - 3. The left solenoid is energized.
- 436 - 4. The flexible jet pipe and the control spool.
- 436 - 5. The control spool will move to the right.

- 437 - 1. a.
- 437 - 2. b.
- 437 - 3. b.
- 437 - 4. c.
- 437 - 5. c.
- 437 - 6. c.
- 437 - 7. c.

- 438 - 1. two.
- 438 - 2. To trap the fluid in the actuator.
- 438 - 3. Yes.

- 439 - 1. To reduce damage to mechanisms by preventing the actuator from slamming into its end of travel with great force.
- 439 - 2. The sleeve (C) which covers the snub valve passageways (J).
- 439 - 3. Between the fully extended and the fully retracted positions.
- 439 - 4. On seat.
- 439 - 5. The sleeve (C) covers the snub valve passageways (J) by the snub spring operator (L).

- 440 - 1. Internal locking actuators would be used on aircraft where limited space is available.
- 440 - 2. To extend or retract a mechanism, then lock it in position.
- 440 - 3. The locking plunger.
- 440 - 4. Pressure must be applied to force the locking plunger away from the locking balls.
- 440 - 5. They spring up behind the piston lips.
- 440 - 6. It extends to the right, thus locking the toggles in place.
- 440 - 7. The toggles.
- 440 - 8. The lock rod piston (J).

- 441 - 1. The automatic position control system automatically repositions itself to neutral; the non-automatic system must be manually positioned after a system has been used.
- 441 - 2. Nonautomatic.
- 441 - 3. Automatic.
- 441 - 4.
 - a. (2)
 - b. (1)
 - c. (3)
 - d. (2)
 - e. (3)

- 442 - 1. Manual, manual-hydraulic, and electro-hydraulic.
- 442 - 2. The bypass valve.
- 442 - 3. Energized.
- 442 - 4. The autopilot servoram (J).
- 442 - 5. It pushes the centering link (F) away from the main bellcrank when pressure is applied. This lets the main bellcrank pivot when the push rod is moved.
- 442 - 6. The balance link (I).

- 443 - 1. Flow is directed into the motor rather than from it. The motor does not have a foot valve.
- 443 - 2. Flow control valve.
- 443 - 3. Selector valve.
- 443 - 4. The jackscrew is simply a nut that travels on the threads of the screw.
- 443 - 5. To change the angle at which the rotary motion is transmitted.
- 443 - 6. Most hydraulic motors do not have foot valves; instead, any leakage past the pistons is directed back to return through the case drain port.

- 444 - 1. Rack and pinion, vane.
- 444 - 2. Stationary, moveable, wingshaft.
- 444 - 3. Wingshaft, pinion.

CHAPTER 5

- 445 - 1. (1) c.
- (2) d.
- (3) b.
- (4) a, b, d.
- (5) c.

- 446 - 1. To control the rate of fluid flow in the system.
- 446 - 2. The pressure on the back side of the piston decreases.
- 446 - 3. The difference of pressure on either side of the piston.
- 446 - 4. No. Because, before this could happen, the pressure behind the piston would become equal to the pressure in front of it.
- 446 - 5. Gallons per minute (gpm).
- 446 - 6. No.

- 447 - 1. The flow equalizer works on the principle of difference in pressure.
- 447 - 2. To the left.
- 447 - 3. To the right.
- 447 - 4. It should center itself between the left port and the right port.

- 448 - 1. It stops the flow of fluid after a certain amount of fluid has passed through it.
- 448 - 2. It determines the amount of fluid that will flow through the valve before it fuses.
- 448 - 3. There is less pressure on the back side of the piston than on the front.
- 448 - 4. The check valve is used to permit reverse fluid flow if the fuse is installed in alternating lines.
- 448 - 5. No. We always use a fuse with a slightly larger capacity than the actuator requirements.
- 448 - 6. Type I.
- 448 - 7. Type II.
- 448 - 8. Type II.
- 448 - 9. Type I.

- 449 - 1. 1500 psi.
- 449 - 2. The excess pressure will force the reservoir return valve to go off seat and send the excess pressure to return.
- 449 - 3. 1500 psi.
- 449 - 4. 1500 psi.

- 450 - 1. T.
- 450 - 2. F. They are usually located as close as possible to the unit to be actuated.
- 450 - 3. F. A typical shuttle valve usually has three ports.
- 450 - 4. F. Pressure from one system or the other helps to hold the shuttle up against the seat.
- 450 - 5. T.
- 450 - 6. F. Although the shuttle is the only sliding part, the retaining ball and spring will move each time the shuttle moves past them.

- 451 - 1. Mechanical, electrical, and pressure.
- 451 - 2. Sequence valve.
- 451 - 3. To allow one operation to be performed before the rest of the system can operate.
- 451 - 4. The sequence valve (B) is open, and the actuator valve (E) is extended.
- 451 - 5. Up through the valve to the actuator.

- 451 - 6. The actuator (E) is retracting, which opens the spoiler.
- 451 - 7. Closed.
- 451 - 8. Actuator F is moving left to the unlatched position. Because switch G is closed the fluid to actuator C is shut off, preventing actuator C from moving.
- 452 - 1. It is used to transfer fluid from a fixed point to a moveable point.
- 452 - 2. It not only can rotate 360° around its lateral axis, but it will extend and retract also.
- 452 - 3. Seals.
- 452 - 4. Friction.
- 452 - 5. Piston rod.

CHAPTER 6

- 453 - 1. (1) g.
(2) b.
(3) f.
(4) q.
(5) n.
(6) k.
(7) i.
(8) j.
(9) d.
(10) c.
(11) l, e
(12) m.
(13) p.
(14) u.
(15) a.
(16) o.
(17) s.
(18) h.
(19) e.
(20) k.
- 454 - 1. Compression stroke, fully extended.
- 454 - 2. Recoil valve.
- 454 - 3. When the thinnest part of the metering pin is in the orifice.
- 454 - 4. The air is compressed and acts like a spring to absorb the shock.
- 454 - 5. Metering tube.
- 454 - 6. Metering pin or tube.
- 454 - 7. The nose gear can be steered by using the steering collar, and the nose gear usually has some type of centering device such as centering cams.
- 454 - 8. Because the main gear on most aircraft are not used for steering. The torque arms hold the strut in the proper position.
- 454 - 9. To align the nose gear in the proper position for retraction of the gear.
- 454 - 10. Disengaged.
- 454 - 11. It transmits the force from the steering damper to the torque links. The torque links then position the inner cylinder of the strut in the desired direction.
- 455 - 1. The piston type.
- 455 - 2. The check valve is on seat.
- 455 - 3. The check valve will be forced off seat.
- 455 - 4. Through the filler plug on top of the reservoir.
- 455 - 5. Reservoir section and working chamber section.
- 455 - 6. The spring forcing down on the replenishing piston.
- 455 - 7. The replenishing piston forces fluid through the replenishing check valve into the working chambers.
- 455 - 8. By an orifice passageway.
- 455 - 9. Through the orifice passageway.

- 456 - 1. Centering spring.
- 456 - 2. Left-hand cylinder chamber.
- 456 - 3. The housing will move to the left.
- 456 - 4. The compensator.
- 456 - 5. Poppets C and D.
- 456 - 6. The steering engaging valve.
- 456 - 7. It acts an ordinary vane shimmy damper.
- 457 - 1. T.
- 457 - 2. T.
- 457 - 2. T.
- 457 - 4. T.
- 457 - 5. F. The anti-cavitation check valves will open during violent shimmy action to prevent cavitation.
- 457 - 6. T.
- 458 - 1. It is usually not connected to the main hydraulic system. It has its own reservoir, master cylinder, and brake.
- 458 - 2. It is forced out into the brake lines.
- 458 - 3. The large spring (E).
- 458 - 4. The master cylinder must be applied, and then the parking T-handle must be pulled.
- 458 - 5. The compensator is nothing other than a spring-loaded accumulator. When thermal expansion builds up, it will compress the spring. When fluid is lost, the compensator will force more fluid into the system.
- 458 - 6. Simple reapply the brakes.
- 458 - 7. The amount of applied force on the brake pedals.
- 458 - 8. Fluid from the reservoir can flow down through the passageway and fill the chamber with fluid.
- 459 - 1. T.
- 459 - 2. T.
- 459 - 3. F. Load feel is built into the brake system so that the pilot is aware of the amount of braking action being applied.
- 459 - 4. F. Thermal expansion will force the piston (H) down and relieve the excess pressure into the return line.
- 459 - 5. T.
- 459 - 6. T.
- 459 - 7. F. The pressure will simple be routed to return. The slave metering valve then meters main system pressure to the brake assembly. A mechanical looking mechanism in the pedal linkage will hold the brakes in the parked position.
- 460 - 1. T.
- 460 - 2. T.
- 460 - 3. T.
- 460 - 4. F. He pushes down on a master cylinder which forces fluid to the slave brake control valve.
- 460 - 5. F. The master cylinder forces fluid to the slave brake valve.
- 461 - 1. It prevents wheel skid.
- 461 - 2. It is centered between the two nozzles.
- 461 - 3. Pressure will build up on area a_2 , which will force control spool to open area a_3 .
- 461 - 4. Area A_2 .
- 462 - 1. It provides a means of rapidly applying and releasing the brakes.
- 462 - 2. The lower area of the deboster is 3.5 times that of the upper area.
- 462 - 3. Approximately 333 psi, or 1/3 the applied pressure.
- 462 - 4. Check valve and opening pin.
- 462 - 5. By opening the shutoff valve located in the line between the inlet pressure and deboost pressure ports.

- 462 - 6. Air vent.
- 462 - 7. It is returned through the brake control valve to the reservoir.
- 463 - 1. (1) d.
(2) g.
(3) i.
(4) e.
(5) f.
(6) h.
(7) j.
(8) a.
- 464 - 1. To prevent warping of the rotor.
- 464 - 2. To maintain the proper running (OFF) clearance.
- 464 - 3. $\frac{1}{4}$ inch.
- 464 - 4. Yes.
- 464 - 5. Segmented rotors.
- 464 - 6. Piston.
- 464 - 7. Return spring.
- 464 - 8. As the brakes wear, the brakes will eventually fade.
- 464 - 9. By checking the length of the adjuster pin.
- 464 - 10. Stators, pressure plate, and backing plate.
- 465 - 1. More of the wheel disc of the spot disc brake is exposed to the air than is the case with the segmented rotor and multiple disc brakes.
- 465 - 2. The return spring.
- 465 - 3. Adjust to give the proper running (OFF) clearance.
- 465 - 4. The brakes could drag.
- 465 - 5. By checking the length of the adjusting pins.
- 465 - 6. Backing plate and piston.

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S T O P -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
42354 03 21
PNEUDRAULIC COMPONENTS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

42354-03-21

MULTIPLE CHOICE

1. (400) The purpose of the finger screen in a reservoir is to
 - a. filter the fluid as it returns to the reservoir.
 - b. filter out foreign material from the air entering the reservoir.
 - c. prevent foreign matter from entering the reservoir during servicing.
 - d. filter the fluid before it enters the power pump.
2. (400) The purpose of a standpipe in a reservoir is to
 - a. protect the pump.
 - b. supply the pump during inverted flight.
 - c. reserve fluid for the power pump.
 - d. reserve fluid for the emergency pump.
3. (401) A centrifugal-type pump consists of
 - a. two gears in a housing.
 - b. two vanes in a housing.
 - c. an empeller in a housing.
 - d. pistons and cylinder block.
4. (401) The reason that a centrifugal-type pump does not need a relief valve installed in the system is that
 - a. the compensator will regulate the pressure.
 - b. it has clearance between the impeller and the housing.
 - c. the pressure regulator will regulate the pressure.
 - d. the pump will stall when the pressure exceeds the pressure limits.
5. (402) If a hydraulic reservoir is pressurized to 25 psi, what would be the minimum pressure in psi in the return line to the reservoir?
 - a. 24.
 - b. 25.
 - c. 27.
 - d. 50.
6. (403) Before any maintenance is performed on a reservoir that is pressurized with air, what should be done?
 - a. The accumulator system pressure should be dumped.
 - b. The air pressure regulator should be adjusted.
 - c. The air pressure inside the reservoir should be dumped.
 - d. The reservoir should be drained of fluid.
7. (403) What is used to maintain the proper air pressure inside an air pressurized reservoir?
 - a. Compensator.
 - b. Air pressure regulator.
 - c. Air flask.
 - d. Relief valve.

42354-03-21

8. (404) During one complete cycle of a double displacement-type hand pump, fluid is drawn in through the supply line on
- both strokes and forced out on one stroke.
 - one stroke and forced out on both strokes.
 - both strokes and forced out on both strokes.
 - one stroke and forced out on one stroke.
9. (405) What is used to prevent damage to the engine if an engine-driven hydraulic pump should jam?
- Slip clutch.
 - Pressure regulator.
 - Pump drive shaft shear section.
 - Variable-restrictor control valve.
10. (405) If a new constant-volume, piston-type pump with two foot valves is drawn from supply and indicates the wrong direction of rotation, you must
- rotate the valve plate head 180° only.
 - install an accessory drive of correct rotation.
 - reverse the suction and pressure connections only.
 - rotate the valve plate head 180° and reverse the suction and pressure connections.
11. (406) Fluid output of the Vickers variable-displacement pump is determined by the
- rpm of the drive shaft.
 - position of the pilot valve.
 - spring tension on the internal relief valve.
 - angle between the drive shaft and the cylinder block.
12. (406) What happens as the drive shaft rotates on a stratopower pump?
- Both the cylinder block and pistons rotate.
 - The universal link and cylinder block rotate.
 - The pistons are stationary, and the cylinder block rotates.
 - The pistons move back and forth, and the cylinder block is stationary.
13. (406) In the stratopower variable volume pump, what holds the pistons in constant contact with the creep plate?
- Fixed pivot.
 - Creep plates.
 - Nutating plate.
 - Stationary bearing.

42354-03-21

14. (407) When installing an automatic check valve, what should you do to insure that the valve is installed properly?
- a. Make sure that the arrow marked on the valve housing is pointing in the direction of fluid flow.
 - b. Make sure that the arrow marked on the valve housing is pointing in the opposite direction to the flow of fluid.
 - c. Adjust the spring tension so the valve will open at the specified pressure.
 - d. Make sure that fluid flows in one direction only.
15. (408) Quick disconnect couplings are used in pneudraulic systems to
- a. allow for bleeding of the system.
 - b. prevent the loss of pressure when a unit is removed.
 - c. prevent the loss of fluid when connecting and disconnecting a line.
 - d. prevent any fluid loss in the event of a broken line.
16. (409) In a motor-operated shut-off valve, what automatically shuts the motor off when it reaches the desired position?
- a. Limit switches built in the shut-off valve.
 - b. Sequence valve.
 - c. Manual return spring.
 - d. Pressure switch in the system.
17. (410) Refer to figure 2-13 of the text. Which of the following situations is most likely to occur in the hydraulic pressure regulator when it is kicked in and the power pump is running?
- a. Pressure below the piston is decreasing.
 - b. Pressure on top of the piston is decreasing.
 - c. The check valve is open, the bypass is closed.
 - b. The check valve is closed, and the bypass is open.
18. (410) A leaking check valve in a pressure regulator will cause the valve to
- a. kick in sooner.
 - b. kick out later.
 - c. kick in later.
 - d. kick out sooner.
19. (411) What is the difference in construction, if any, between a main system relief valve and a thermal valve (TERV)?
- a. Thermal relief valves are larger.
 - b. The system relief valve is smaller.
 - c. The thermal relief valve is smaller.
 - d. There is no difference.

42354-03-21

20. (411) If a relief valve with a ball seat area of $1/6$ sq. in. is to relieve 1,800 psi, the spring tension would
- be 1,800 pounds.
 - have no effect on the cracking pressure.
 - be 300 pounds with no back pressure.
 - be 1,500 pounds with back pressure.
21. (411) Most relief valves are adjusted to
- reseat pressure.
 - full flow pressure.
 - cracking pressure.
 - back pressure.
22. (412) The screen in a diaphragm type accumulator is to
- make the diaphragm stronger.
 - keep air from entering the fluid side.
 - clean the air entering the accumulator.
 - prevent the diaphragm from extruding into the fluid line.
23. (413) During the initial starting of the engine pump in a self-displacing-type accumulator hydraulic system, what prevents the pump from being starved of fluid?
- Compensator.
 - Hand pump.
 - Storage chamber of the self-displacing accumulator.
 - Return line check valve.
24. (414) A filter assembly with a differential pressure indicator operates upon what principle?
- The increase of fluid viscosity as the temperature is lowered.
 - The spring-loaded magnetic indicator piston pip-up when contaminated.
 - The collection of contaminated particles on the outside of the filter elements.
 - The difference in pressure entering the element and pressure after it leaves the element.
25. (415) In the fluid cooler assembly, fluid will flow directly from the fluid inlet port to the fluid outlet port when the temperature of the hydraulic fluid is, if anything,
- high.
 - low.
 - unknown.
 - none of the preceding.

42354-03-21

26. (416) Hydraulic manifolds are used in a hydraulic system to provide a location where
- common fluid lines can come together.
 - the return lines can join together only.
 - the pressure lines can join together only.
 - the hydraulic test stand can be connected.
27. (416) Refer to figure 2-27 of the text. On the selector valve manifold discussed in the volume, what is used to prevent installing the wrong valve on the manifold?
- Arrows showing the direction of flow.
 - Alignment pins.
 - Different size valves.
 - Different size fittings.
28. (417) When the air compressor's oil pressure drops, the bleed valve will be positioned to
- connect the in port to the drain port.
 - connect the drain port with the system pressure port.
 - route the oil overboard.
 - shut off the compressor.
29. (418) The heating element of the moisture separator is used to
- remove the moisture from the air.
 - heat the air before it is routed into the system.
 - prevent freezing of the moisture in the reservoir.
 - actuate the pressure switch to the dump valve.
30. (419) Besides serving as an air storage bottle, the air flask can be used to
- store a reservoir supply of hydraulic fluid.
 - trap moisture in the pneumatic system.
 - regulate the pneumatic pressure in the system.
 - absorb the pressure surges in the hydraulic system.
31. (419) In regard to a chemical drier, a desiccant is
- | | |
|--------------------------|-------------------------|
| a. a drying agent. | c. a filter. |
| b. an electrical switch. | d. a special lubricant. |

42354-03-21

32. (420) Assume that while you were releasing the pressure from a pneumatic system component, the air servicing valve blew off. What could possibly have caused this to happen?
- a. The valve core was depressed.
 - b. The body nut was loosened first.
 - c. The swivel nut was loosened too much.
 - d. Excessive thermal expansion in the system.
33. (420) When releasing the air pressure in a pneumatic system that uses an MS-28889 air servicing valve, you should
- a. remove the valve core first.
 - b. depress the valve core.
 - c. turn the swivel nut clockwise.
 - d. turn the swivel nut counterclockwise only.
34. (421) If pressure is applied to a bourdon tube, most likely the tube will
- a. straighten out.
 - b. collapse.
 - c. coil.
 - d. curve back to its original shape.
35. (422) The wall thickness and stiffness of the bourdon tube used in a direct-reading pressure gage will determine the
- a. range of the pressure gage.
 - b. burst pressure.
 - c. pressure setting of the system.
 - d. amount of flow in the system.
36. (423) The face of a pressure gage indicates 1 through 5, and just below this "psi X 100." What would be the maximum psi pressure indication of this gage?
- a. 5,000.
 - b. 500.
 - c. 50.
 - d. 5.
37. (424) The purpose of a snubber in a hydraulic pressure indicating system is to
- a. restrict the fluid leaving the pressure gage or transmitter.
 - b. prevent the pressure transmitter or gage from being damaged from pressure surges.
 - c. prevent the fluid pressure from reaching the pressure gage or transmitter.
 - d. allow free flow to the pressure gage or transmitter.

42354-03-21

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38. (425) Which of the following components is not ordinarily a part of the mechanical sensing section of a transmitter?
- a. Bourdon tube.
 - b. Mechanical linkage.
 - c. Sector gear.
 - d. Stator.
39. (426) What happens as the wiper contact arm is repositioned on the resistance strip of the position indicating transmitter?
- a. The resistance will increase and change the position of the indicator.
 - b. The current will increase and change the position of the indicator.
 - c. The voltage will create a magnetic field, which will change the position of the indicator.
 - d. The voltage will create a restraining force on the rotor.
40. (427) What will occur as fuel flow increases through a fuel flow transmitter?
- a. The displacement of the vane will decrease.
 - b. The vane will shut off the flow.
 - c. The displacement of the vane will increase.
 - d. The vane will bypass the fuel flow.
41. (428) In a liquid quantity indicating system, what moves up and down inside the reservoir as the level of the fluid varies?
- a. Float.
 - b. Piston.
 - c. Air charge.
 - d. Spring.
42. (429) The operation of the electrical differential pressure indicating system discussed in this course depends on the movement of the
- a. transducer diaphragm.
 - b. float.
 - c. wiper arm.
 - d. indicator rotor.
43. (430) Refer to figure 3-10 of the text. If the normal system fails, which pressure switch prevents the changeover to the alternate system if there is not enough pressure in the alternate system?
- a. H.
 - b. M.
 - c. P.
 - d. K.
44. (431) When heat is applied to a bimetallic strip, the strip will
- a. bend.
 - b. straighten out.
 - c. flatten.
 - d. corrode.

45. (432) A manual poppet-type selector valve is in a working position when the camshaft is rotated to
- a. seat all four of the poppets.
 - b. unseat all four of the poppets.
 - c. seat both of the pressure poppets.
 - d. unseat one pressure poppet and one return poppet.
46. (433) In a solenoid operated selector valve, the function of the solenoids is to
- a. prevent external leakage.
 - b. center the spools in the valve.
 - c. position the spools in the valve.
 - d. replenish fluid lost during system operation.
47. (434) A "full-trail" selector valve would
- a. trap the fluid in the alternating lines.
 - b. allow the fluid in the alternating lines free flow back to return.
 - c. allow fluid from one alternating port only free flow back to return.
 - d. allow free flow of fluid from the pressure port to return.
48. (434) In order to trap the fluid in the alternating lines of a selector valve, which of the following selector valves would you use?
- a. Closed center.
 - b. Full-trail.
 - c. Half-trail.
 - d. Non-trail.
49. (435) The danger of using the manual override of a solenoid operated selector valve is that it
- a. could short circuit the valve.
 - b. is possible to bypass the safety features in the electrical circuit.
 - c. will automatically dump system pressure.
 - d. could cause the system pressure to exceed the specified limits.
50. (436) The difference between a selector valve and a servo valve is that the
- a. selector valve is larger.
 - b. servo valve is electrically operated.
 - c. servo valve will control the flow of fluid.
 - d. selector valve has four ports.

42354-03-21

51. (436) Refer to figure 4-11 of the text. When the jet pipe is positioned so that the flow of fluid is directed into the right receiver pipe, which direction, if any, will the control spool move the route fluid to the right cylinder port?
- a. To the left.
 - b. It will remain stationary.
 - c. To the right.
 - d. Up and down.
52. (437) A double-acting unbalanced actuator is used on the aircraft because it provides
- a. equal pressure in two different directions.
 - b. the high pressure needed to overcome the extra spring force.
 - c. more force in one direction than in the other.
 - d. a means of having a mechanical lock on the unit.
53. (438) The advantage of using a tandem actuator, especially on primary flight control systems, is that
- a. one side of the actuator can be used by the pilot while the other can be used by the co-pilot.
 - b. in case one hydraulic system malfunctions the other system will be able to operate the flight controls.
 - c. it will lock the flight controls in a neutral position if either hydraulic system should fail.
 - d. it will create more force when extending than when retracting.
54. (439) Refer to figure 4-15 of the text. Whenever there is full flow through this type of actuator, the
- a. sleeve (C) has completely covered the passageways (J).
 - b. sleeve (C) has completely uncovered the passageways (J).
 - c. orifice restrictor is on seat.
 - d. snub spring operator (L) has positioned the snub valve closed.
55. (440) Refer to figure 4-17 in the text. Which of the following methods can be used to unlock and extend the toggle-lock actuator?
- a. Apply pressure to the lock bleed port and extend port at the same time.
 - b. Apply pressure to the unlock cylinder and then allow it to extend by spring action.
 - c. Bleeding the pressure from the hydraulic lock side and letting the weight extend the actuator.
 - d. Mechanically unlock the unit and then apply pressure to extend it.

42354-03-21

56. (441) How is the selector valve in a nonautomatic hydraulic actuating system controlled?
- a. By microswitches.
 - b. By electrical sequencing.
 - c. By mechanical sequencing.
 - d. Manually by the operator.
57. (441) In a differential followup system, the followup action will catch up and neutralize the selector valve when the
- a. mechanical input stops.
 - b. electrical input stops.
 - c. actuators are at their extremes.
 - d. countermechanical movement is exerted.
58. (442) Refer to figure 4-21 in the text. The component which allows the fluid to flow from one side of the main actuator to the other when in the manual mode is the
- a. solenoid operated shut-off valve (C).
 - b. flapper type servo valve (K).
 - c. bypass valve (M).
 - d. servo ram (J).
59. (443) In order to change the direction of rotation of a hydraulic motor, what should be done?
- a. The head should be rotated 180° .
 - b. Change the direction of fluid flow into the motor.
 - c. Change the foot valves.
 - d. The flow regulator will have to be replaced.
60. (444) Refer to figure 4-25 of the text. Which part of the rack and pinion actuator, if any, rotates?
- a. Both the rack and pinion.
 - b. The rack only.
 - c. The pinion only.
 - d. Neither the rack or pinion.
61. (445) The purpose of an orifice in a hydraulic system is to
- a. regulate the pressure in each sub-system.
 - b. limit the travel of each actuator.
 - c. limit the rate of fluid flow.
 - d. limit the rate of fluid flow in one direction only.
62. (446) Hydraulic flow regulators regulate fluid flow
- a. in one direction only.
 - b. in both directions.
 - c. only when there is no load on the actuator.
 - d. only when there is maximum load on the actuator.

42354-03-21

63. (447) If fluid does not split evenly in the flow equalizer, a
- a. free-floating piston shifts position.
 - b. variable orifice changes opening size.
 - c. check valve opens on the side with less pressure.
 - d. check valve opens on the side with greater pressure.
64. (448) Hydraulic fuses are used in aircraft systems to
- a. maintain a constant rate of flow to a subsystem.
 - b. prevent any fluid loss in the event of a broken line.
 - c. prevent excessive fluid loss in the event of a broken line.
 - d. prevent excessive rate of flow to a subsystem in which it is installed.
65. (449) What happens when a counterclockwise movement of the adjust: screw on the pressure reducing valve is made?
- a. Metered pressure increases.
 - b. System pressure drops to zero.
 - c. Operating pressure decreases.
 - d. Main system pressure is isolated from the subsystem.
66. (450) Which hydraulic system valve is normally installed at the inlet port to allow two independent systems to operate the same actuator?
- a. Slide type selector.
 - b. Combining check.
 - c. Balanced relief.
 - d. Shuttle.
67. (451) Refer to figure 5-23 in the text. If the selector valve is positioned to direct fluid to the extend side of actuator D, in what position are sequence valves?
- a. Sequence valve B is open and sequence valve C is open.
 - b. Sequence valve B is open and sequence valve C is closed.
 - c. Sequence valve B is closed and sequence valve C is closed.
 - d. Sequence valve B is closed and sequence valve C is open.
68. (451) In a typical electrically sequenced system, what unit is used to insure proper sequencing?
- a. Priority valve.
 - b. Sequence valve.
 - c. Microswitch.
 - d. Thermal switch.
69. (452) Which component can be used to transfer fluid pressure from a fixed point to a moveable point?
- a. Bulkhead fitting.
 - b. Shuttle valve.
 - c. Swivel.
 - d. Manifold.

70. (452) Besides rotating 360° around its lateral axis, the balanced extension unit will
- a. extend and retract also.
 - b. relieve excess pressure buildup.
 - c. allow one system to operate before another.
 - d. be used as a shock strut.
71. (453) What is used on a strut to remove mud or dirt from damaging the seals in the strut?
- a. A scraper ring.
 - b. A felt wiper.
 - c. A backup ring.
 - d. The lower bearing.
72. (453) The primary purpose of the torque arms used on aircraft landing gear struts is to
- a. keep the wheels in the correct alignment.
 - b. keep the gear aligned for retraction.
 - c. limit the maximum extension of the strut.
 - d. allow the wheels to turn when steering the aircraft.
73. (454) Other than the weight of the gear, what forces the inner cylinder to extend?
- a. The recoil valve.
 - b. The metering pin and orifice.
 - c. Hydraulic fluid pressure.
 - d. Nitrogen pressure.
74. (454) What function does the recoil valve of an aircraft strut serve?
- a. Prevents rapid rebound of the strut.
 - b. Prevents rapid retraction of the strut.
 - c. Restricts the fluid flow when the strut is compressing.
 - d. Restricts the fluid flow on both the compression and extension stroke of the strut.
75. (454) When the nosegear shock strut is fully extended, the nosewheel and axle assembly are lined up in the straight ahead position by the
- a. torque arm.
 - b. telescoping cylinders.
 - c. fork and axle assembly.
 - d. upper and lower centering cams.

42354-03-21

76. (455) Shimmy dampers work on the principle that
- a. free flow will prevent shimmy.
 - b. free flow will prevent air from getting into the system.
 - c. restriction to flow will prevent shimmy.
 - d. restriction to flow will prevent air from getting into the system.
77. (456) In addition to nosewheel shimmy control, what feature is found on most aircraft with nose gear?
- a. Dual tires installed for safety.
 - b. Nosewheel steering.
 - c. Nosewheel braking.
 - d. Mechanical retraction.
78. (456) When the vane steering damper unit is not being used, the unit becomes
- a. completely inoperative.
 - b. a shimmy damper.
 - c. a recoil valve.
 - d. stationary.
79. (456) A followup system is used with nosewheel steering to
- a. give the pilot "load feel."
 - b. permit the aircraft to be towed.
 - c. keep the nosewheel in the desired position.
 - d. return the nosewheel to the straight-forward position.
80. (457) The purpose of the centering springs on the steering metering valve is to
- a. hold the control valve in neutral position in the damping mode.
 - b. center the compensating valve.
 - c. hold restrictors in neutral position.
 - d. center the shock strut to neutral position.
81. (458) Refer to figure 6-14 in the text. How is the thermal expansion relieved when the brakes are in the OFF position?
- a. Fluid is routed from the main system to return.
 - b. By a compensator installed in the line to the brake.
 - c. Fluid is routed from the brake pressure line to return.
 - d. Fluid is routed from the main system to the brake pressure line.

82. (459) The unit in an integral brake system that directs main system pressure to the brakes is the
- a. power brake control valve.
 - b. master cylinder.
 - c. deboost valve.
 - d. anti-skid valve.
83. (460) Which of the following options is incorrect concerning a slave brake system on an aircraft?
- a. It provides less of a fire hazard.
 - b. It reduces the weight of an aircraft.
 - c. It eliminates high pressure entering the cockpit.
 - d. It is heavier than a simple power braking system.
84. (461) The unit that will be installed in the brake system to automatically release the brakes when a wheel skids is
- a. a deboost valve.
 - b. a power brake control valve.
 - c. a master cylinder.
 - d. an antiskid valve.
85. (462) If a deboost is said to have a 3:1 ratio, this indicates that
- a. the delivered volume is increased three times over the applied volume.
 - b. the delivered pressure is increased three times over the applied volume.
 - c. it is used to operate three brake units from one PBCV.
 - d. it has three inlet ports and one outlet.
86. (462) What is installed in a deboost unit to automatically replenish the fluid in the lower chamber?
- a. Recoil valve.
 - b. Check valve and opening pin.
 - c. Shut-off valve.
 - d. Relief valve.
87. (463) The main disadvantage of multiple disc brakes is that they
- a. are hard to maintain.
 - b. are less efficient than other brakes.
 - c. are not self-adjusting.
 - d. have poor heat dissipating qualities.

88. (464) If the automatic adjuster clamp of the segmented rotor brake is loose, the brake
- a. cannot be applied.
 - b. will tend to drag.
 - c. eventually will not apply.
 - d. eventually will lock when applied.
89. (465) The spot disc brake components whose condition is most important for proper self-adjusting are the
- a. torque nut and spring guide.
 - b. piston and cylinder surfaces.
 - c. adjusting pin and adjusting pin grip.
 - d. adjusting pin and internal retaining ring.
90. (465) If the adjusting pin torque nut on a spot disc brake is too tight, which of the following situations will result?
- a. The brakes will drag.
 - b. Braking action will eventually be lost.
 - c. The lining clearance will decrease.
 - d. The adjusting pin will be forced inward.

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AIRCRAFT PNEUDRAULIC SYSTEMS MECHANIC

(AFSC 42354)

Volume 4

Pneudraulic Systems



Extension Course Institute

Air University

599

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND
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Preface

TO PROPERLY troubleshoot hydraulic systems, it is necessary for you to know how to read and use schematics. Do you become confused and bewildered when opening a technical order to study a hydraulic system? These feelings are sometimes common to those who are just starting their careers as 3-level mechanics. But there is no need for such confusion if you follow a logical sequence when studying the schematic. In this volume, we are going to show you how to study a schematic in a logical step-by-step sequence. It is the same sequence that you should follow when studying your own hydraulic system. Of course, as we go along, we will explain the path of fluid flow and the purpose of each unit. Understanding of the system's operation is a must in order to study schematics.

Since it is impossible to discuss the hydraulic and pneumatic systems on each and every aircraft in the Air Force's inventory, we have selected schematics that will offer broad coverage, yet are simple enough to understand. Some of these schematics have been simplified purposely and should not be used in lieu of the appropriate technical order schematic diagrams.

Included as a supplement to this volume are 11 foldouts. Whenever you are referred to one of these foldouts in the text, please turn to the supplement and locate it.

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This volume is valued at 21 hours (7 points).

Material in this volume is technically accurate, adequate, and current as of January 1978.

Contents

	<i>Page</i>
<i>Preface</i>	iii
<i>Chapter</i>	
1 Pseudraulic Power Systems	1
2 Landing Gear and Related Systems	16
3 Aircraft Flight Control Systems	41
4 Inflight Refueling System	60
<i>Answers for Exercises</i>	79

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Pneudraulic Power Systems

A PNEUDRAULIC pressure supply system furnishes the pressure to operate such systems as the landing gear, nose wheel steering, brakes, flight controls, etc. Subsequent chapters of this volume contain detailed information concerning the constructional features and operation of these systems. Unfortunately, not all the aircraft systems can be talked about in this course, so we have selected hydraulic systems that are used on some of our most worked upon aircraft.

What part do you play in maintaining a pneudraulic system? You make scheduled inspections, operational checks, and sometimes use a hydraulic test stand to determine if the system is operating properly. In addition, you are responsible for certain servicing jobs, such as filling hydraulic reservoirs, cleaning filters, and inflating pneumatic air bottles.

To do these jobs efficiently, you must have a thorough knowledge of the construction features and principles of operation of aircraft pneudraulic systems. You have already obtained much of this information in your resident school training, and we will review each system we talk about in this volume. To begin, let's first look at how the hydraulic power system operates and trace the fluid as it flows from unit to unit.

1-1. Aircraft Hydraulic Power Systems

In this section, we talk about specific examples of hydraulic power systems. We show you how they function and the purpose of the individual units. We also examine the types of units used in various aircraft hydraulic power systems. First, we talk about the construction and operation of a hydraulic power system used on a larger type of aircraft. Many of the large aircraft are multiengine that usually present problems you would not normally find on the lighter single engine aircraft. Larger aircraft may have many additional valves that normally would not be found in a single engine aircraft. As an example, multiengine aircraft have engine shutoff valves that shut down one or, in some cases, several engines and still maintain

flight. The second system that we will discuss is a hydraulic power system found on a fighter (lighter) type of aircraft. Although similar to the larger aircraft power system, it is quite different.

600. Given specific operations of the hydraulic power system, identify the component that performs the particular operation and specify multiengine system constructional/operational features.

Hydraulic Power System Components. The hydraulic power supply system we talk about provides hydraulic power to operate the aileron, rudder, and elevator booster cylinders. The hydraulic booster assemblies are not considered as part of the hydraulic power supply system and will not be talked about in this chapter. We discuss how the booster assemblies operate when we talk about the flight controls later on in this volume. Now refer to foldout 1 (bound in separate inclosure).

We will start this discussion with the reservoir and proceed through the rest of the system. The reservoir has a capacity of 2.0 gallons of hydraulic fluid. A sight level gage mounted on the reservoir gives a visual indication of the reservoir fluid quantity. A filler neck with a removable cap is provided for servicing the reservoir with fluid. An air vent filter is located at the top of the reservoir to filter the air entering the reservoir. A drain valve at the bottom of the reservoir provides manual overboard draining of the reservoir fluid. A flexible hose connects the reservoir to the suction boost pump because of the severe vibration of the pump. The suction boost pump is a centrifugal-type pump driven by a 3-phase, 400-cycle, AC induction motor. The suction boost pump has a shaft seal drain that empties into a drip pan. The drip pan has a manual drain valve to dump the fluid in the drip pan overboard. The suction boost pump produces a large volume of fluid at a low pressure. As an example: 20 gpm at 90 psi, which is more than enough to insure a

positive supply of fluid to the engine-driven pumps. From the suction boost pump, you will notice a line that tees off and goes to a 2-way restrictor and check valve. This is the suction boost bypass line. It continuously circulates fluid from the suction boost pump back to the reservoir to provide a cooler operating boost pump. Just below the bypass line is a line going to the low-pressure warning switch. When suction boost pump discharge pressure drops below the low limit, the switch is actuated, causing an amber warning light on the hydraulic control panel to illuminate. Notice the ground on the warning light. This is the push-to-test-light circuit. When the indicator light is pushed, it completes a circuit to the ground that will automatically turn the light on (if the light is good).

Now let's return to the hydraulic system. The ground test connection below the bypass line is furnished to allow a hydraulic test stand to be attached to the aircraft for ground testing. The check valve just below the ground test connection prevents draining the suction lines to the pumps when the suction boost pump is shut down. After passing through the check valve, the suction boost pump pressure flows to two identical hydraulic systems. For simplification we'll only talk about the components in the No. 3 system. The fire wall shutoff valve shuts off hydraulic supply to the pumps in case of fire emergency. The valve is motor operated with two positions: OPEN and CLOSED. With the valves open, fluid can flow to the engine-driven variable volume pumps. The pump has four lines attached to it: pressure, suction, case drain and shaft seal drain. When the pump shaft seal leaks, the fluid is routed overboard. The case drain line routes internal pump leakage through the 20 psi relief valve back to the reservoir. When the engine pump is running, fluid under pressure (3000 psi) leaves the pressure port of the pump and flows through a filter assembly. This filter is of the *no bypass* type. If the filter element becomes clogged, it causes a filter indicator button to protrude. Fluid now flows through a solenoid operated shutoff valve. This valve is spring loaded to the OPEN position and energized closed by the same switch used to close the fire wall shutoff valve. When both the fire wall and solenoid shutoff valves are closed, notice that fluid cannot flow from the suction boost pump, nor can it flow into the pressure system. Since the pump is always engaged by the engine accessory drive section, the fluid would become extremely warm after a prolonged period of time. To remedy this, there is a check valve between the suction and return line just above the No. 3 engine pump. The fluid that normally leaves the case drain line can now flow back to the suction side of the pump. The reason for this is that the spring in the check valve offers less resistance than the 20 psi relief valve. So rather than the fluid from the case drain line returning to the reservoir, it flows back through the check valve and into the suction side of the pump. This is called a run-around circuit that cools the fluid and keeps the engine-driven pump lubricated.

A low-pressure warning switch is installed in the pressure line of each engine-driven pump. When pump discharge pressure drops below the low limit, the switch actuates and causes a warning light on the hydraulic control panel to glow. Downstream from the pressure switch is another check valve. This valve has three jobs. First, it prevents fluid from one hydraulic system pump from entering the other hydraulic system pump. As an example, if the No. 3 system was off but the No. 4 system pump pressure was reading 3000 psi, the fluid from No. 4 system could not flow to the No. 3 system pump. Without this check valve installed where it is, fluid from one system could motorize (cause the engine-driven pump to turn) the pump. Secondly, without the check valve, you could not determine which system was inoperative because the pressure switch would be actuated even though only one system was operating. Third, the first component downstream from the check valve is the ground test connection for the pressure hose of the hydraulic test stand. Notice that pressure from the ground test connection cannot flow to the pumps because of the check valves. Once the fluid passes the pressure line check valve, the fluid flows to the accumulator, relief valve, and pressure transmitter. The relief valve is set at 3450 psi. Any pressure in excess of this amount would be routed back to the reservoir through the return line filter. The accumulator has a 50-cubic-inch capacity with a 1500 psi precharge. A snubber is installed in the pressure line to the transmitter. The electrical power for the pressure transmitter comes from the booster hydraulic pressure circuit breaker.

Hydraulic Power System Operation. Prior to starting the engines, the suction boost pump switch should be placed to the ON position. This is the top switch on the copilot's instrument panel, as shown in foldout 1. This allows electrical power to flow from the hydraulic boost suction pump control circuit breaker to the suction pump relay solenoid and then to ground. When this happens, it pulls all three contacts down. When this happens, power is available to the suction boost pump motor, which in turn operates the centrifugal suction boost pump. Fluid is drawn from the reservoir and sent into the suction pressure line. The warning light should be on until the boost pump pressure builds up sufficient pressure to open the contacts of the pressure switch. With the boost pump pressure built up, the engines can now be started.

To open the fire wall shutoff and solenoid operated shutoff valves, the engine pump switches must be placed to the ON position. This completes an electrical circuit from the copilot's circuit breaker panel, through the engine pump switches, ice detector relay contact to the open side of the motor operated fire wall shutoff valve. The solenoid operated shutoff valve is spring loaded to the OPEN position, so simply dropping the electrical power will position it to OPEN. With the fire wall shutoff valve open, fluid from the suction boost pump can flow to the engine-driven pump. The pump produces a fluid flow through the

pressure in-line filter and the solenoid operated shutoff valve to the pressure switch. If the pressure is high enough, the pressure will force the contacts in the pressure switch to break the ground for the warning light, and the light will go out. Fluid then flows out through the check valve in the pressure line to the pressure transmitter, accumulator, and relief valve. Notice that just about everything is duplicated in the 2-system except for the three components just mentioned above. These components are used for both systems. If either one of the hydraulic systems is operating (System No. 3 or No. 4), fluid would be available to the pressure transmitter, relief valve, and accumulator. There are two ways of electrically closing the suction shutoff and solenoid operated shutoff valves. One is by pulling the fire control handles, and the other is to place the engine pump switches to OFF.

Let's discuss the fire control handles first. When the fire control handles are pulled, they complete a circuit to the solenoid in the ice detector panel (as shown on foldout 1). The solenoid pulls the contact in the relay down, completing the circuit to the fire wall shutoff valve motor and the solenoid operated shutoff valve. As you can see, even though the pump switch is ON, power flows through the contact in the ice detector panel and tees off to the fire wall shutoff valve and to the solenoid operated shutoff valve and closes both valves. When this happens, the pressure warning light for that system will come on when system pressure drops off. To again open the valves, simply push the fire handles back in. This method of shutting off the pressure is not recommended because, besides shutting off the hydraulic suction and pressure, it also shuts off the fuel to the engine. Of course with the fuel shut off, the engine will stop. The recommended method of checking the pressures in the system is simply by placing the appropriate engine pump switch to the OFF position. Notice that each pump switch has two contacts. With the switch in OFF position, the indicator light automatically finds a ground through the lower contact of the switch. The other contact completes a circuit that allows electrical power to flow from the circuit breaker to the close side of the suction shutoff valve and solenoid operated shutoff valve. To open the valves again, simply place the switch to the ON position. This will open the suction shutoff and deenergize the solenoid of the solenoid operated shutoff valve.

Exercises (600):

Using foldout 1, answer the following questions:

1. What is installed in the vent line of the reservoir to prevent contamination from entering the reservoir?

2. Why is a hose used to connect the reservoir to the suction boost pump?
3. Hydraulic supply lines to the engine-driven hydraulic pumps are pressurized by a _____.
4. Why does the suction boost pump have a bypass line?
5. When the amber low-pressure warning light comes on, what does this indicate?
6. Visually, how can you detect a clogged in-line pressure filter?
7. What unit prevents system pressure from actuating the low-pressure warning switch of a failed engine-driven hydraulic pump?
8. If a fire occurs, what provisions does the hydraulic system have to cut off the supply of fluid to the pumps?
9. Explain why a run-around circuit is used when the hydraulic pump shutoff valves is closed.
10. Name the two ways of shutting off fluid flow into the engine-driven pumps.

601. Describe or explain hydraulic power system components in terms of purpose, function, quality, or operational characteristics.

Hydraulic System Components and Operation. In the simplest hydraulic systems, fluid stored in a reservoir is pumped, under pressure, by an engine-driven pump to an actuator, then returned to the reservoir. For smoothness of operation, components such as accumulators, pressure surge suppressors, and

snubbers are added. Control devices like check valves and control valves are added for ON/OFF operation. For information and safety, indicators, fuses, relief valves, warning systems, and radiators are used. For this discussion, refer to foldout 2.

As stated earlier, this particular power supply system has many features that were not on the previous schematic we just discussed. Here again, we start our discussion with the hydraulic reservoir and proceed from there. This reservoir is an airless type designed to be pressurized by hydraulic system pressure. The reservoir has a manual air bleed valve used to bleed any air from the reservoir. An overboard drain is provided to route fluid overboard when the reservoir is mistakenly overserviced with fluid. Notice also that it has two return lines, one of which has a drain fitting. The pressure line is attached to the reservoir in order to force the piston (shown as the shaded area) in the reservoir to the right. As the piston moves to the right, it pressurizes the fluid. This fluid, under pressure, leaves the bottom line of the reservoir and flows toward the engine-driven pump. On its way, notice that the fluid must pass a quick disconnect with a cap. This is where the suction (return) hose of the hydraulic test stand would be connected. Just past the ground test connection, notice that the fluid divides and flows to two engine-driven pumps.

Since these two systems are identical, let's trace the fluid through the bottom hydraulic system only. This will simplify our discussion. Now, as the fluid tees off, notice that it flows through the suction quick disconnect of the pump. The pump is a variable volume pump capable of producing 26 GPM flow at full flow condition and is set to maintain system pressure of 3000 psi. The pump has hoses (not shown) that are located between the pump fluid ports and the quick disconnects. If metal tubing were placed in these locations, the metal tubing would be damaged because of pump vibration and engine movement.

Now trace the fluid flow from the case drain line back to the reservoir. Notice that it passes through a quick disconnect at the right side of the pump to the case drain filter assembly. This particular filter assembly is the *no bypass* type, but it has a contamination indicator button that protrudes when the differential pressure rises too high. Next, it flows through a check valve and down to the hydraulic fuel radiator. The radiator is nothing other than a cooling coil that has fuel running through it. Even though both the fuel and hydraulic fluid flow through the radiator, they are separated by thin tubing. This allows the fuel to pick up any heat from the hydraulic fluid, thus cooling the fluid as it returns to the reservoir. Notice that the only fluid that flows through the radiator is the fluid from the case drain lines of the engine-driven pumps. Now let's talk about the fluid that is produced under pressure from the engine-driven pump. As each piston in this pump reaches its full stroke (approximately 562 times per second) it produces a natural "ripple" (pulse). This is a normal characteristic of piston-type pumps. If this pulse is not reduced, it could

cause a destructive type of vibration being set up in the main part of the hydraulic system. To eliminate this problem, a surge suppressor is installed in the pressure line from the pump. The surge suppressor does not contain any air as does an accumulator to counteract the pressure surges. It is simply a round metal globe that causes the fluid to change its natural direction of flow, by bouncing, splashing, and agitating the fluid from the pump. This action produces an acceptable pump pulse. From the surge suppressor, fluid flows through the pressure quick disconnect. Notice that quick disconnects are installed on all the lines on the pump. This will make the changing of the pump easier.

The next component in the pressure line is the low-pressure warning switch. Whenever the system pressure is low, the switch will complete a circuit from the *warning light* circuit breaker panel to the *check hydraulic gauges warning light*. When the pressure is high enough, it will break the contact and turn the light out. Fluid from the pressure lines next goes through a check valve and filter assembly that has a bypass and contamination indicator button. The accumulator is a piston type with a precharge of 1000 psi. Fluid flows from the accumulator and goes out to the subsystems but also tees off and goes into the system manifold. The manifold has several components built into and attached to it. Notice that the system pressure runs into two check valves, one of which prevents fluid to flow through it while the other allows the pressure to flow through it to the filter assembly. Notice also the pressure quick disconnect at the bottom left of the manifold. This allows the connection of the hydraulic test stand pressure hose. Whenever the test hose is not connected to the aircraft, the quick disconnect dust cap must be installed to prevent contamination of the system. From the filter assembly, fluid flows to the main system relief valve. If the pressure builds up in excess of system operating pressure, the relief valve will open and route the excess pressure back to return. As the pressure leaves the manifold, notice that it can flow out into the subsystem again. Also, it flows to a hydraulic fuse through a snubber to the pressure transmitter. The pressure transmitter sends an electrical signal to the cockpit pressure indicator. Now look at the lower right side of the system manifold. Notice a quick disconnect with a dust cap attached. This particular quick disconnect is used to service the reservoir with fluid, using a portable hydraulic servicing cart. The cart, when attached, sends fluid through the quick disconnect and filter assembly. The filter assembly insures that the fluid used for servicing the reservoir is clean. As the fluid fills the reservoir with fluid, it forces the piston (shaded area) to the left. Attached to the piston are some markings that indicate the amount of fluid in the reservoir. When the piston moves to the left far enough to the correct indicator mark, then the hydraulic servicing cart can be disconnected. Remember to put the dust cap back on the quick disconnect after the hydraulic servicing cart is removed.

Exercises (601):

Use foldout 2 in order to answer the following questions.

1. Explain how the reservoir is pressurized.
2. Why are quick disconnects attached to the pumps?
3. State the reason for having hoses instead of metal tubing on the pumps.
4. Describe the purpose of the surge suppressor.
5. What will cause the CHK HDY Cages warning light to illuminate?
6. As stated in the text, from which unit does the flow of hydraulic fluid come from before entering the hydraulic/fuel radiator?
7. Explain how the heat from the hydraulic system is transferred to the fuel in the radiator.
8. When the hydraulic reservoir is serviced, using the portable hydraulic servicing cart, where would the cart be attached?
9. List at least four different components in or attached to the system manifold.
10. If the transmitter was to burst, what is installed in the system to prevent draining the complete hydraulic system?

1-2. Pneumatic Power System

Each manufacture of an aircraft determines what components, systems, style, type, etc., of aircraft to build. One manufacturer might want all hydraulic systems, while another may want all pneumatic

systems. Still another may want a combination of each.

In the early types of aircraft, a pneumatic system consisted of an air flask (charged to a specified pressure) used to operate one or more systems in emergency. As you will see in the following chapters in this volume, pneumatic systems can be, and in many cases are, much more complicated than this. In this section we are going to talk about the pneumatic power system components and system operation.

602. Specify constructional/operational features of various pneumatic components in the pneumatic power system.

Pneumatic Power Supply System. In this discussion we have selected a pneumatic system that has just about everything you would normally find in a pneumatic system. Refer to figure 1-1. This system is a high (3000 psi), self-sustained pneumatic system that supplies compressed air to the various pneumatic subsystems. Figure 1-1 only shows the pneumatic power supply system. Later on in this volume we will show how these subsystems operate when we talk about the landing gear and flaps. But for now though, we concentrate only on the pneumatic power supply system.

Pneumatic system components. The air compressor maintains the aircraft pneumatic system's pressurization during flight. The air compressor is driven by a hydraulic motor powered by the utility hydraulic system. Compressor operation is controlled by the pneumatic system's manifold pressure sensing switch. The compressor cuts in when system pressure drops to 2750 psi minimum, and cuts out when system pressure reaches 3050 to 3200 psi.

The moisture separator is capable of removing up to 95 percent of the moisture from the air compressor discharge line. The automatically operated condensation dump valve purges the separator oil-moisture chamber by means of a blast of air (3000 psi) each time the air compressor shuts down. The condensation dump valve solenoid is energized and deenergized by a pressure switch. When energized, it prevents the air compressor from pumping air overboard; when deenergized, it completely purges the separator reservoir and lines up to the air compressor. A filter protects the dump valve port from becoming clogged and thus insures proper sealing of the passage between the reservoir and dump port. An internal check valve protects the system against pressure loss during the dumping cycle and prevents back flow through the separator to the air compressor during the relief condition. The relief valve opens when system pressure reaches 3500 psi and reseats at 3250 psi to protect the system against overpressurization and thermal expansion.

The chemical air drier used in the high pressure pneumatic system further reduces the moisture

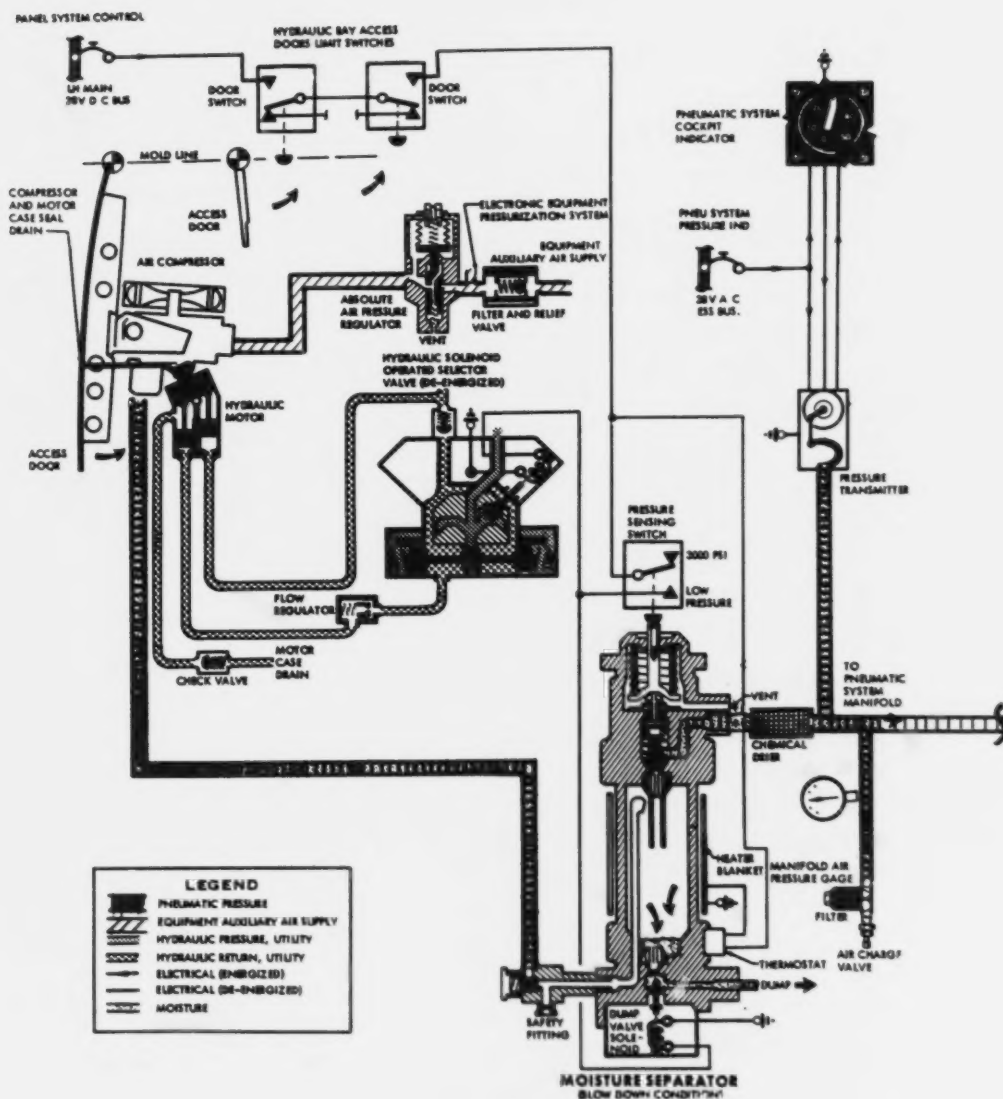


Figure 1-1. Pneumatic power supply.

content of air emerging from the moisture separator. It also serves to reduce the amount of air compressor lubricating oil and foreign material entering the subsystems.

An air servicing (schradler) valve is installed in the pneumatic system for the purpose of servicing the system while the aircraft is on the ground. The air filter in the ground charge line prevents the entry of impurities into the system from the ground servicing source. The air pressure gage, adjacent to the ground servicing valve, indicates the pressure of the system.

The hydraulic system consists of a solenoid-operated selector valve, flow regulator, hydraulic motor, and motor bypass (case drain) line check valve. When the selector valve is energized, it allows hydraulic fluid under pressure to run the hydraulic

motor. Deenergized, the selector valve blocks off hydraulic pressure, which stops the motor. The flow regulator meters the flow of fluid to the hydraulic motor, preventing excessive speed variation and/or overspeeding of the compressor. A check valve in the motor bypass line prevents system return line pressure from entering the motor, thus preventing motor stall.

Pneumatic system operation. Notice in figure 1-1 that the air compressor is mounted to the access door. When the door is down (as shown) the lubricating pump inside the compressor would not lubricate all the moving parts properly. To prevent operating the compressor while the door is down, two switches are used to break the electrical circuit in the pneumatic system. Let's assume that the access doors are closed and the switches are actuated closed to complete the

electrical circuit. Notice that the electrical power flows from the 28 VDC bus circuit breaker through the door access switches and down to the pressure sensing switch and heating blanket thermostat. If the temperature is low, the thermostat allows the electrical power to proceed on to the heating blanket. The heating blanket prevents the moisture inside the moisture separator from freezing. If the pressure sensing switch is closed, notice that power can energize the moisture separator dump valve and the solenoid operated hydraulic selector valve. When the solenoid operated selector valve is energized, it directs hydraulic fluid under pressure through the flow regulator to the hydraulic motor attached to the air compressor. As the motor turns, it causes the compressor to build up pneumatic pressure. Notice the seal drain on the access door. Any leakage of the shaft seal of the hydraulic motor will come out this area.

The equipment auxiliary air system supplies the air compressor with air when the engines are operating. This insures an adequate supply of air to the compressor at all altitudes. The auxiliary air is first filtered through a high-temperature 10-micron filter that has a built-in relief (bypass) valve. After it flows through the filter, it enters a pressure regulator. The air pressure regulator provides a stabilized source of air to the inlet port of the air compressor. The air compressor being run by the hydraulic motor compresses the inlet air and sends it out the pneumatic pressure line to the moisture separator. Since the solenoid on the bottom of the moisture separator is energized closed, the pneumatic pressure will flow up through the check valve and out to the exit port. The pressure will next flow through a chemical drier and out into the pneumatic system manifold. Notice also that the pressure can flow to the pneumatic system pressure transmitter, which sends an electrical signal to the pressure indicator in the cockpit.

When pressure builds up to the specified amount in the system, the pressure switch on top of the moisture separator opens. When this happens, the solenoid on the hydraulic selector valve deenergizes, and the air compressor hydraulic motor stops running. At the same time, the solenoid on the bottom of the moisture separator is also deenergized. The dump valve automatically springs open. When this happens, any moisture in the moisture separator is dumped overboard. The system will remain in this position until the pressure decreases enough to cause the pressure switch to be activated again.

Exercises (602):

1. Explain why the air compressor should not be operated while the access door is hanging down.
2. What provides a stable pressure head to the air compressor inlet port?

3. If the shaft seal is leaking on the hydraulic motor, how would this be indicated?
4. If the temperature is below freezing, what prevents the moisture in the moisture separator from freezing?
5. What components are provided for external servicing of the pneumatic system?
6. What protects the dump valve port of the moisture separator assembly from becoming clogged?
7. If the air compressor was overspeeding, what could possibly have caused this malfunction?
8. What two components are energized when the moisture separator pressure switch is closed?

1-3. Pneudraulic Power Supply Maintenance

Because of the numerous components found in the hydraulic/pneumatic power supply system, it would be impossible to talk about the maintenance performed on each and every component. We have selected specific items that we feel are common to just about every hydraulic power supply system. In this section we go over general procedures used to inspect, service, perform operational checks, and remove and replace components.

603. Specify specific hydraulic power system item inspection requirements and the procedures to follow in servicing specific items.

Inspection. When inspecting the pneudraulic power system, one of the first things you should look at is the reservoir. It is serviced properly? Is it low? An aircraft that repeatedly returns from a mission with a low reservoir could indicate that there is a leak in the system. Check the air charge in the accumulator. Check all the components for leakage, mounting, and safety wiring. Check tubing and hoses for damage. If filters are installed in the power system, check to see if the filter buttons are popped, which would indicate

clogged filters. More detailed inspection procedures can be found in the applicable aircraft -6 technical order.

Servicing. The servicing section of the applicable -2 TO contains instructions for servicing the various systems and components of the aircraft. In addition to the TO information, symbol markings are used to identify servicing points, ground handling locations, and hazardous areas. Figure 1-2 illustrates the servicing and ground-handling markings. Notice, for

instance, that these markings show where you would place a jack for jacking an aircraft or attach a servicing cart to service a reservoir. Depending on the background color, servicing markings are either black or white. The ground-handling markings are an orange-yellow color with a black or white outline. Here we cover general procedures that can be used to service accumulators and reservoirs.

Accumulators. In order to better understand how to service an accumulator with air, refer to figure 1-3.

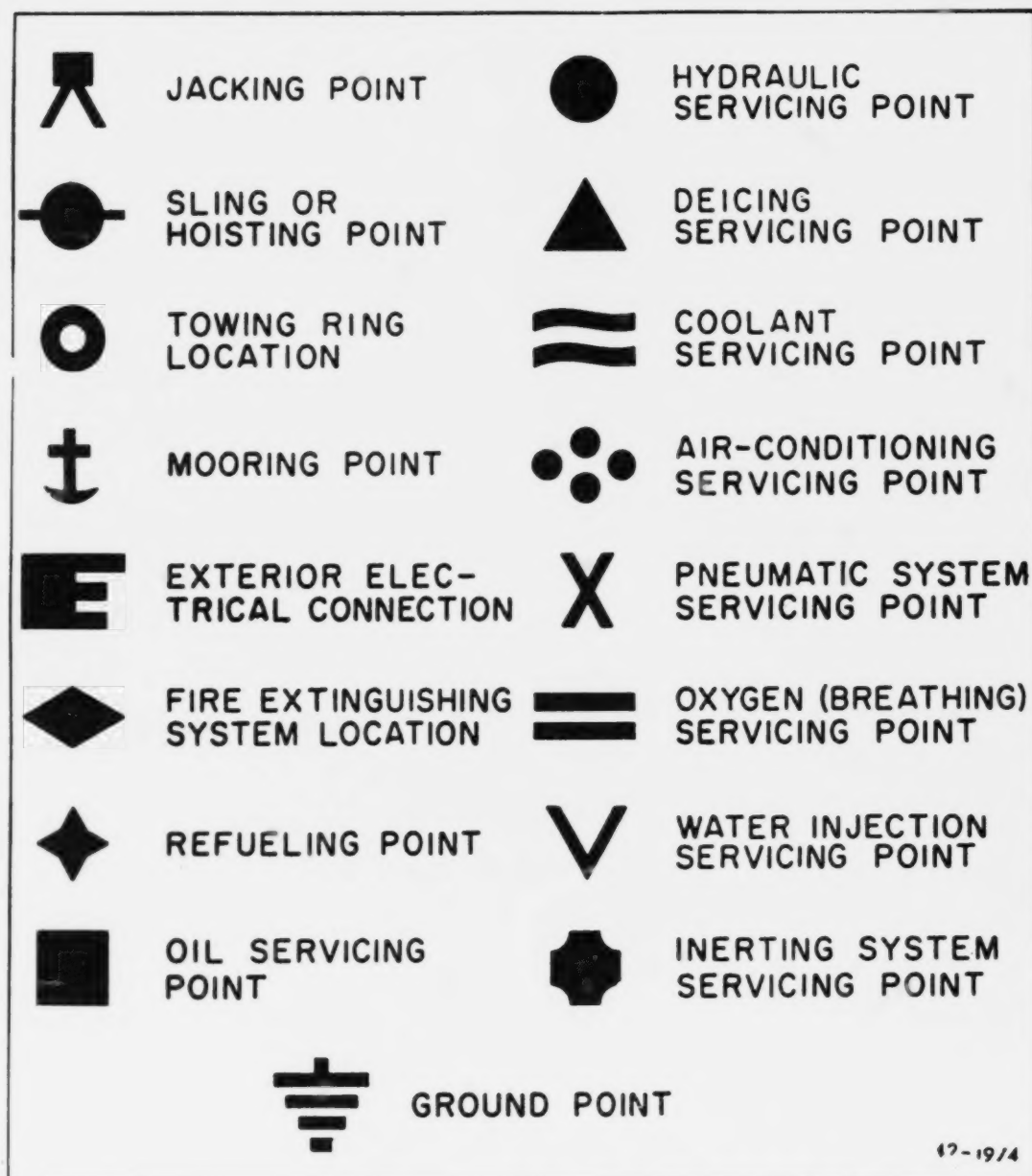
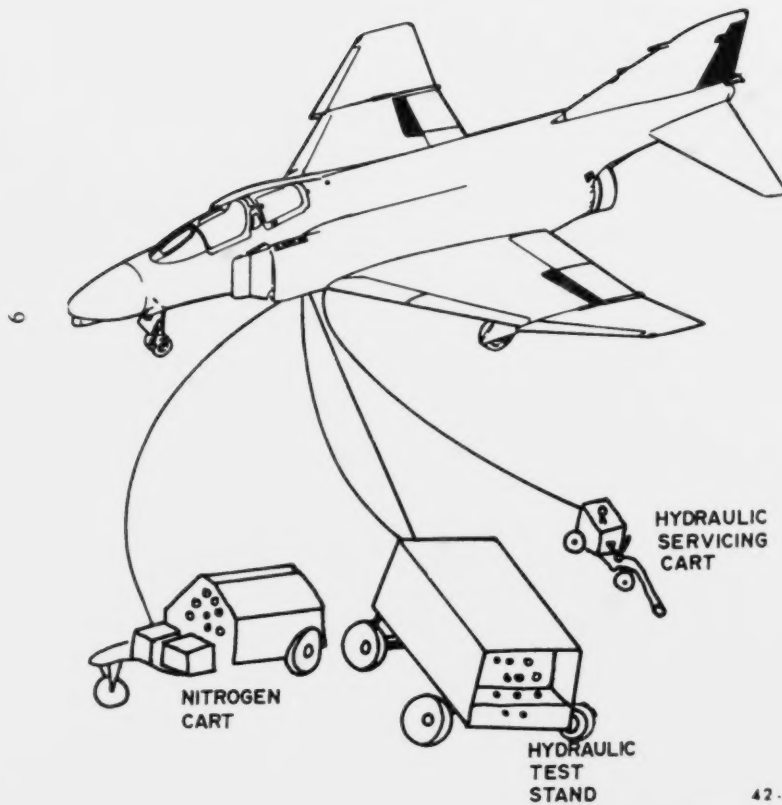
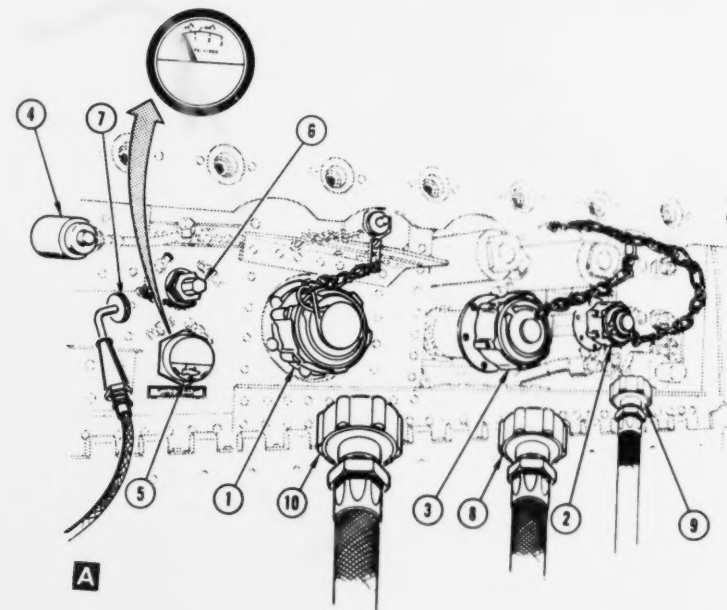


Figure 1-2. Ground-handling and servicing markings.



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Figure 1-3. Pneudraulic servicing points.



Notice the nitrogen servicing cart, which can be used in place of an air compressor to service an accumulator with air. Notice also in the insert, how the air servicing air chuck (7) is used to connect the air servicing hose to the air servicing valve (6).

When you find that an accumulator needs servicing (charging with dry air or nitrogen), begin by depressurizing the hydraulic system. This is to make sure that you get an accurate measurement of the air charge. Some other names of the air charge that are put in the accumulator are "initial air charge" and "preload." Next, remove the air servicing valve cap and connect the external pneumatic power source to the accumulator air charge valve. Loosen the air charge valve swivel nut (MS28889 schrader valve). Charge accumulator to specified air charge given in the applicable TO. An important point to remember is that the amount of air pressure placed in the accumulator depends upon the ambient temperature. If you will recall, temperature will affect a gas by expanding it as the temperature rises and contracting it as the temperature falls. When the gas in an accumulator expands, the pressure increases; and as the gas contracts, the pressure decreases. For example, assume that an accumulator requires an initial air charge of 1000 psi at 70° F. On this particular day, the sun is very hot and the ambient temperature is 100° F. If you put 1000 psi in the accumulator disregarding the temperature, the gas will contract as it cools and, as it does, the pressure will decrease. Let's go a little farther and say that it cools down to 70° F. Instead of the accumulator having 1000 psi at 70° F, it might have only 920 psi, a pressure decrease of 40 psi. This could cause the accumulator to bottom each time an excessive amount of hydraulic pressure is applied to the accumulator. Notice the air servicing gage (5) on figure 1-3 that indicates the amount of air pressure in the accumulator. After charging the accumulator, tighten the swivel nut on the servicing valve, disconnect the air chuck, check for leaks, and install valve cap. It should be noted that each accumulator will have different preloads, but the servicing procedures just discussed are basically the same for any hydraulic accumulator.

Reservoirs. To insure that the reservoir is serviced properly, use the aircraft TO or follow the instructions on the data plate. The data plate is usually located close to the reservoir being serviced. These instructions tell you the type of fluid that should be used, the position of the system, and the system pressure that must exist before you start to service the reservoir. For example, if system pressure is 3000 psi instead of zero psi, the reservoir may seem low because some of the fluid is now stored in the accumulator. Also if you check the fluid level with the subsystems in the wrong position, the reservoir may indicate too much or not enough fluid. The reason for this is that some actuating cylinders displace more fluid when they are retracted than when they are extended.

The method used to service a hydraulic reservoir is primarily determined by the reservoir type and

location. Some are serviced by removing a cap or plug from the filler port and pouring fluid directly into the reservoir. Another type of reservoir is serviced with a pressure servicing cart or a hydraulic test stand. Refer to figure 1-3 as we cover how to service a reservoir using a servicing cart. First, relieve the system pressure by operating one of the aircraft's subsystems, (brakes, flight controls). With the pressure depleted, check the air charge in the system accumulator. Service the accumulator if necessary before servicing the reservoir. The hose (9) from the hydraulic servicing cart shown in figure 1-3 is attached to the quick disconnect (2) as shown in the insert of figure 1-3. With the servicing cart connected to the aircraft, pump the fluid into the reservoir. Do not pump the fluid into the reservoir too fast, because this could rupture the reservoir. Notice the air bleed valve (4) that is used to release any trapped air in the reservoir. This valve should be depressed while pumping fluid into the reservoir until a steady stream of clear hydraulic fluid flows from the air bleed valve drain line (not shown). You would then continue pumping fluid into the reservoir until the reservoir is serviced with the specified amount. Now notice the hydraulic test stand in figure 1-3. It too can be used to service a reservoir with fluid. In the insert, the hydraulic test stand hoses (8) and (10) can be attached to quick disconnects (1) and (3). Using the test stand's fill system, pump fluid through the test stand hoses to fill the reservoir.

Exercises (603):

1. Besides the TO, what else can be used to indicate servicing points on an aircraft?
2. What is the first step that should be done when accumulator needs to be serviced with air?
3. What should an accumulator be inspected for?
4. Generally speaking, if an accumulator is normally serviced with 1000 psi of air at 70° F. should the pressure be increased or decreased if the ambient air is 30° F?
5. Name the two items that can be used that give instructions on servicing a reservoir.
6. List three things that are usually found on a data plate for servicing a reservoir?

7. When using a servicing cart to service a reservoir, what could possibly happen if you pump the fluid into the reservoir too fast?

8. List some items that could cause the reservoir to indicate that the reservoir is low.

9. How could you tell if a filter was clogged during an inspection?

10. What general requirements can all components be inspected for?

604. Identify the source of hydraulic/pneumatic power for an operational check from given situations, and specify general operating principles about a hydraulic power supply system.

Operational Checks. You can perform an operational check of the hydraulic power system by either connecting a hydraulic test stand to the aircraft or running the aircraft engines. Figure 1-3 shows how a hydraulic test stand would be connected to an aircraft. If a hydraulic test stand is used, it can usually check everything in the system except for the hydraulic pumps themselves. In order to check the pumps, either the engines will have to be run or the pumps removed from the aircraft and bench checked in the shop. When an operational check is required on a pneumatic system, an air compressor is usually connected to the aircraft in order to pressurize the system. Here again, depending on the system, the air compressor should be able to pressurize the complete system.

As we said, the other way of performing an operational check of the hydraulic power system is to run the engines. With the aircraft engines running, you can check everything in the system except for the relief valves. The reason for this is that the compensators in the pumps are set at a certain amount while the relief valve is set to relieve excessive pressure (above the pump compensator setting). With the engines running, you would never be able to reach the relief valve setting to check it for proper operation. To give you an idea on what you should look for or do when performing an operational check, the following list is provided.

Prior to operational check:

- Get the appropriate technical order.
- Gather all the test equipment tools required for the check.

- Check the fluid level in the reservoir.
- Check the air charge in the accumulators.
- Many warning lights have push-to-test circuits. Test the lights to insure that none is burned out. Many man-hours have been spent troubleshooting a system when only the light bulb had burned out.
- Check the position of the controls and circuit breakers.

During operation:

- Check to see that the pressure rises smoothly during engine startup, and that the warning lights go out at specified pressure settings.
- Verify the pressure readings in the cockpit with the pressure readings on the system accumulators. In some cases special test gages have to be installed during the operational check.
- Listen for any unusual noises or sounds. As an example, a hissing noise may indicate by-passing of fluid in the system.
- Look for any external leakage.

After the operational check has been done and the engines are shut down, remove any test equipment that was used.

Exercises (604):

1. Identify by matching the source of hydraulic/pneumatic power source in column B that must be used to perform an operational check of the situation in column A.

Column A

1. Pilot reports that the hydraulic pump is leaking.
2. The schrader valve on the pneumatic servicing connection is leaking.
3. A relief valve was found leaking. It was removed and replaced.
4. An accumulator shows signs of external leakage of hydraulic fluid.

Column B

- a. Run the aircraft engines.
- b. Use portable hydraulic test stand.
- c. Use portable air compressor.

2. You are performing an operational check on an engine-drive pump that has just been replaced. Using this situation and the situations below, come up with the most logical answer.

- The pressure indicator in the cockpit is reading high. You suspect that the indicator is in error. What can you do to verify this?
- The pilot who is performing the engine run asks you what the plus or minus is on the pump pressure. You say that you don't remember. What have you done wrong?

- c. You hear a grinding noise coming from the pump just replaced. After investigation, you determine that the pump is cavitating because of the lack of fluid. What should you have done to prevent this from happening?

605. Specify removal and replacement features of specific units in the pneudraulic system.

Removing and replacing Pneudraulic Components. It would be impossible for us to cover the removal and installation procedures for every component in the pneudraulic power system on every aircraft in the Air Force inventory. We will talk about procedures that are common on such units as the filter, engine drive pump assembly, and a chemical drier cartridge.

Removal and replacing of filter element. Filter elements are normally replaced periodically with a serviceable filter element. This means that at certain intervals these elements are removed and replaced to prevent them from completely clogging up. These filter elements are also replaced when a system is contaminated, or suspected of being contaminated. The following procedures are typical for most aircraft filter elements. Refer to figure 1-4. Relieve system pressure by operating some subsystem (brakes, flight controls, etc.). If the system has a pressurized reservoir, be sure to depressurize it. Next, cut the lockwire and unscrew the filter case (bowl) from the filter head. Pour the fluid in the filter bowl out and check the interior of the case for contamination. Small particles of dirt indicate that the filter element is doing its job. An excessive amount of particles could indicate that the system is contaminated and in need of flushing. (Flushing will be covered later on in this chapter). Next remove the filter elements to check them for damage. A filter element that is damaged (cut, torn) could mean that the filter element is allowing unfiltered fluid into the system.

Prior to installing a new filter element in the filter assembly, install all new O-ring seals. Install the filter element into the head of the filter assembly. Next, wipe the filter bowl clean and fill it with clean hydraulic fluid. (This helps to eliminate the injection of air into the system.) Screw the bowl into the filter head and torque in accordance with the maintenance instructions. Next, safety wire the filter bowl and wipe off any excess fluid. After filter elements are replaced, be sure to pressurize the hydraulic system and check the filter assembly for leaks.

Removing an engine-driven pump assembly. As with the removal of a filter assembly, the hydraulic system pressure should be depleted. Some aircraft hav firewall shutoff valves that should be closed to prevent draining the lines of fluid during pump removal. Next, disconnect the lines to the pump. There are

normally four lines attached to a pump assembly; supply, pressure, case drain, and shaft seal drain. Some aircraft have large clamps that hold the pump in place, while others are held in place by nuts and washers. In any case remove the clamp or nuts and remove the pump from the mounting pad. If a new pump is going to be installed on the aircraft, the fittings must be removed from the old pump and installed in the new pump. Be sure to install the fittings properly. Before the new pump is installed, it should be primed. If a pump is not primed, it could be damaged or send air into the system.

Priming a pump. When priming an engine-driven pump, the air space in the pump is replaced with fluid. This can easily be done by attaching a supply of fluid to the inlet or supply port and rotating the pump shaft until a clear supply of fluid comes out of the pressure port. When the pump is completely full of fluid, there is no way that it can send any air into the system after it is installed.

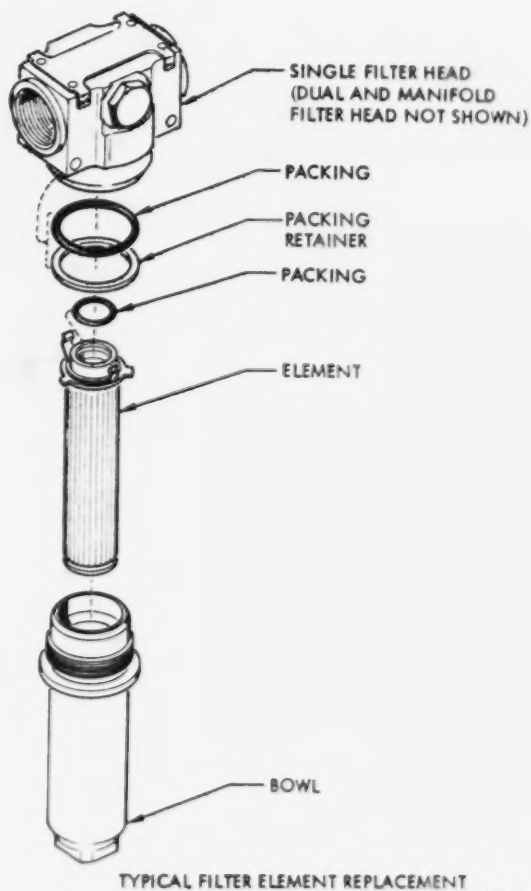


Figure 1-4. Typical filter element replacement.

Installing a pump. After the fittings have been installed and the pump primed, the spline of the pump shaft should be lubricated. This not only makes the pump easier to install into the mount pad but it also keeps the spline from wearing. Many pumps require a seal between the pump mount pad and the pump itself. Be sure to check the TO for the installation of such a seal. Install the pump to the pump mount pad making sure that it is aligned properly. Then install the clamp or nuts that secure the pump to the mount pad. Next install the lines, and wipe off any excess fluid. Because the pump is mounted to the engine, the engine will have to be run to check the pump for leakage and proper pressure readings.

Removing and replacing a chemical drier cartridge. Preventive maintenance of this component consists of replacing the cartridge when it becomes saturated with moisture. As with the filter elements, change them periodically. To replace the cartridge in the chemical drier, use the following procedures. Bleed the air from the system. Remove the plug from the outlet end of the air drier housing and discard the O-ring seal. Next remove the old cartridge from the housing and discard the cartridge.

Clean the interior of housing with cloth saturated in cleaning solvent, then dry the housing with clean, lint-free cloth. Also check the housing for signs of corrosion. Remove the protective covers from the new cartridge. If the protective covers are not removed, air will not pass through the cartridge. Install the cartridge so that the arrow and the word "flow" are pointing in the direction of the outlet port. Then reinstall the outlet end plug and use a new O-ring seal. Next, pressurize the system and check for leaks.

Exercises (605):

1. What are the four lines that are normally attached to a pump?
2. Why is it necessary to prime a pump?
3. Why are the splines on the drive shaft lubricated?
4. After an engine driven pump has been installed, explain why a hydraulic test stand cannot be used to check the pump out.
5. Outline the procedures to follow when replacing a filter element.

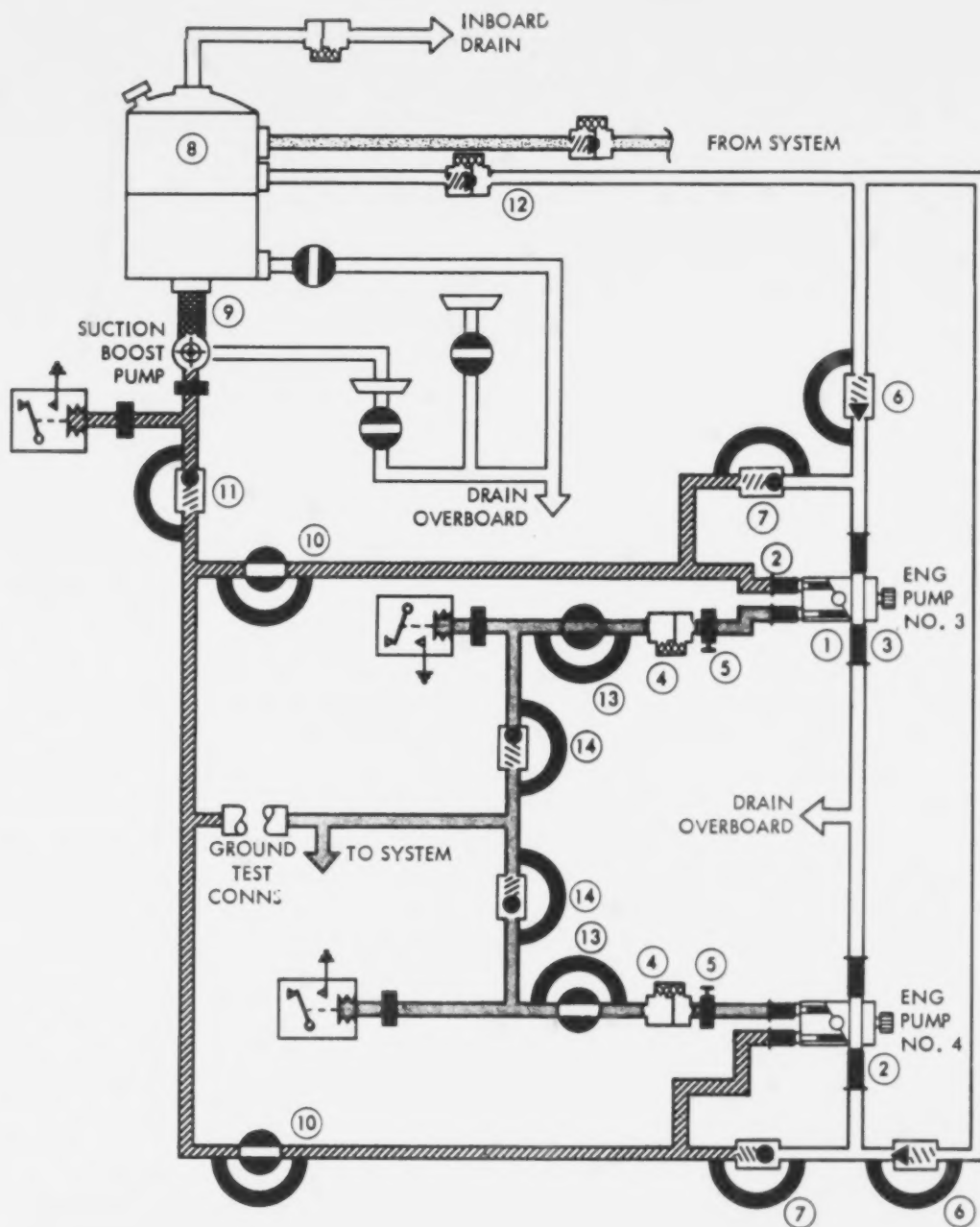
6. Why do you fill the bowl with fluid prior to installing it?
7. Where would you find the torque value on the filter bowl?
8. If the filter bowl was completely filled with dirt particles, what could this indicate?
9. What will happen if the protective covers are not removed from the chemical drier cartridge?
10. Describe the direction the cartridge will be placed into the drier housing.

606. Cite the reason for draining, flushing, and purging; then specify the reason for conducting specific procedures during draining and flushing.

Hydraulic systems should be drained and flushed whenever contaminants are present. The draining and flushing procedures vary somewhat for the different types of aircraft in the Air Force inventory. It is not our interest to cover all the procedures in this section. We will cover procedures that are common and also talk about the trouble that makes flushing and draining necessary.

Fluid Contamination. Whenever it is suspected that a hydraulic system has become contaminated or the system has been operated at temperatures in excess of the specified maximum, make a check of the fluid. Large particles of impurities in the hydraulic system are indications that one (or more) components in the system is (are) wearing. Discoloration of the fluid is another indication that fluid is contaminated, either from being mixed with other fluids or from being overheated.

To determine if the hydraulic system is contaminated, take fluid samples from the reservoir and various other locations in the system. Take these samples in accordance with applicable aircraft manufacturer's instructions for that particular hydraulic system. Some hydraulic systems are equipped with permanently installed bleed valves for taking liquid samples, whereas on other systems, lines must be disconnected to provide a place to take a sample. There are various test procedures used to determine the contamination level in hydraulic fluids. If your shop is equipped



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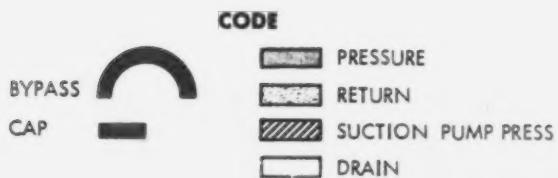


Figure 1-5. Flushing procedures.

with a fluid contamination kit, you can perform the test your self. However, since special equipment is required for these checks, the hydraulic fluid will probably be sent to a laboratory where the contamination test is made.

Draining the Fluid from a Hydraulic System. If the fluid from a contaminated hydraulic system must be drained, you should start with the reservoir first. Most reservoirs have some type of drain that you can open to drain it. If not, a line at the bottom of the reservoir should be loosened just enough to allow the fluid to drain from the reservoir. At all dead-end points from which the fluid cannot be readily drained, open the tubing or hose assembly connections at the fittings to let the fluid drain out. Remove actuating-cylinders valves and other units if the fluid trapped in them cannot be drained by disconnecting a line.

Flushing. Flushing a hydraulic system can be as simple as hooking a hydraulic test stand up to the aircraft and operating the subsystems a sufficient number of times to remove all the contaminated fluid. In other instances, it can get quite involved. To show you how involved flushing a system can get, we cover the flushing procedure of a typical system. Refer to figure 1-5. Let's say that engine-driven pump (1) has failed. First, remove the failed pump and flexible hose assemblies (2) that attach directly to the pump. Next remove and replace the elements in the filter assembly (4). Some valves such as (5) will have to be removed and new ones installed. Other valves will be removed, cleaned, and reinstalled. As you can see on figure 1-5, many of the valves (6, 7, 10, 11, 13, and 14) have been bypassed with flexible hose, and other sections have been capped off. The reservoir (8) will have to be drained. Once all this work has been done, fluid is then forced through the lines to remove any contamination from the system. When the contamination has been removed, the system must be assembled into its original condition. Sound like a lot of work? You bet.

This is why we stress cleanliness of the fluid and the elimination of air in the system.

Purging. Purging is defined as the cleansing of a system. Purging is primarily associated with pneumatic system (gases) as opposed to flushing, which we associate with hydraulic systems (liquids). Even though these two words are used interchangeably, from now on in this course, we will associate flushing with hydraulic systems and purging with pneumatic systems. Purging of a pneumatic system is accomplished by attaching an air source (air compressor or nitrogen cart) to the system and sending air pressure through the system to remove any contamination or condensation from it.

Exercises (606):

1. How can you tell if a system is contaminated?
2. Why is it necessary to disconnect and even sometimes remove some units from an aircraft to properly drain a system?
3. Why is it necessary to bypass some valves when flushing a system?
4. Define purging.
5. What else besides contaminants can be purged from a pneumatic system?

Landing Gear and Related Systems

SOME CARGO aircraft weigh around a quarter of a million pounds without a pound of cargo on them. What do you suppose would happen if the landing gear on such a fully loaded aircraft collapsed as it touched down? The cleanup crew would have quite a job on their hands.

Specifically, what does a landing gear do? At least five things. First, by means of gear retraction mechanisms, it attaches the landing gear to the aircraft structure to enable the gear to extend and retract safely. Second, by means of shock struts, it reduces the shock of landing and taxiing, thus reducing damage to the aircraft structure. Third, by means of a nosewheel steering system, it provides directional control of the aircraft during ground movement. Fourth, by means of a brake system, it stops the aircraft. Fifth, by means of the arresting gear, the aircraft can be stopped if the brakes should fail. You can see, then, that landing gear systems are quite important to aircraft operation.

You perform many duties in maintaining the various systems that comprise an aircraft's landing gear. These duties include: operational checks of the landing gear, brakes and steering systems, and system components. You also perform servicing requirements. Additionally, you remove and replace such components as steering units and brake assemblies. These are the items covered in this chapter. To help fill out the knowledge needed and accomplish your duties, begin by reviewing the arrangement of the landing gear.

2-1. Landing Gear Systems and Components

In the early days of aviation, an aircraft landing gear consisted of two fixed main gears (nonretractable) and a skid undertail assembly. This type of gear was adequate, since these aircraft were slow and rather light. Then, in an attempt to obtain more speed, the gear was first streamlined to cut down on the amount of drag. This helped some; but being ambitious, dissatisfied, and ingenious, the engineers came up with the retractable-type gear. This was a tremendous improvement in drag reduction. Yet, of course, we did not get something for nothing; and, in this case, the weight was increased by the necessary extra linkage and retracting system. As aircraft became faster and heavier, more and more was demanded from the landing gear. But the design engineers have accomplished

their goals. Today's aircraft are equipped with sturdy, smooth, and efficiently operating landing gears.

In this section we begin by reviewing the tricycle and quadracycle landing gear systems, then talk about the antiretraction device, position and warning systems, then large aircraft and fighter aircraft landing gear systems. Last, but not least, we cover the arresting hook system.

607. Specify key operational and structural characteristics of tricycle and quadracycle landing gears.

Landing gears are no longer just a simple set of skids such as the Wright Brothers used on their first aircraft. The state-of-the-art has brought us to the need for much more sophisticated equipment as each new generation of aircraft is developed. Of the various types of landing gear—conventional, bicycle, tricycle, and quadracycle—generally only the last two are used on aircraft today.

Quadracycle Landing Gear. The quadracycle landing gear is used only on the B-52 aircraft. This landing gear might also be called a double bicycle arrangement. It consists of four main gears mounted in the fuselage in the form of a rectangle and two outrigger or tip protection gears, as shown in figure 2-1. The tip protection gears are mounted near the outboard end of the wings to provide for lateral stability during heavy gross weight landings.

Since the quadracycle landing gear is retracted into the fuselage, the main advantage of this arrangement is that it allows for the design of thinner wings. The thinner swept back wing on the B-52 contributes to greater speed. In addition, the position of the main gear units causes the landing forces to be more evenly distributed over the whole aircraft. It also makes use of shorter, yet larger, main landing gear assemblies that, in turn, improve the braking characteristics of the aircraft.

Tricycle Landing Gear. Most aircraft are equipped with the tricycle landing gear. The familiar triangle pattern is not new to most aircraft technicians. The two main gears are usually installed to the right and left of the fuselage centerline. The nose gear is installed at the forward section of the fuselage.



43-507

Figure 2-1. Quadricycle landing gear.

Because aircraft are different in size, shape, and construction, almost every landing gear is of a special design. Even though the gears may be of different designs, the struts of all aircraft having a tricycle landing gear are attached to strong members of the wings or fuselage so that the landing shock is distributed as widely as possible throughout the main body of the structure.

Safety. The old three-point conventional landing gear (two main gear and tail wheel) was all that was available for many years. The problems encountered with it were tolerated because no other choice was at hand. The advent of the tricycle gear system eliminated three of the greatest hazards encountered with the conventional system. First, forward visibility for takeoff and taxiing was improved. Secondly, ground looping was eliminated because of the weight forward conditions of this configuration. The last advantage allowed the hard application of brakes without fear of the "noseover." Later improvements—e.g., anti-skid—completely eliminated any irregular patterns in braking during the landing roll.

Aircraft Land-to-Gear Weight Ratio. The trend had been until the early 1950's to increase the strut, axle, and wheel size to accommodate the increasing demand to carry more weight. The advent of multiple axle, bogie (truck)-type main landing gear solved this problem (see fig. 2-2). This new design incorporated lighter and stronger strut and axle assemblies and increased the number of tires. Three basic advantages were realized by this hallmark in aircraft engineering.

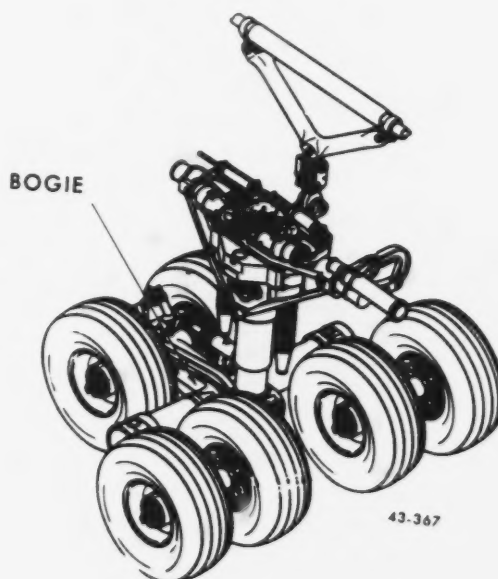
(1) The gross weight of the aircraft was increased nearly twofold without an appreciable gain in weight of the landing gear.

(2) The tire sizes were reduced to more manageable sizes.

(3) The total weight of the aircraft was displaced over a wider area, thus subjecting runways and taxi areas to less damage.

Exercises (607):

1. What are the two types of landing gear configurations used on aircraft?



43-367

Figure 2-2. Bogie (truck)-type gear.

2. Why are the main struts of the tricycle landing gear attached to strong members of the wing or fuselage?
3. What advantages are realized by use of the tricycle landing gear design?
4. What design features are used on today's heavy-weight aircraft landing gear to distribute the greater weights?
5. What two problems were eliminated when the truck and bogie assemblies were introduced?
6. Why are tip protection gears provided on a quadricycle landing gear?
7. What does the quadricycle landing gear system consist of?
8. How is the quadricycle landing gear unique?
9. List the advantages of the quadricycle landing arrangement.

608. Specify the purpose and operational features of the antiretraction device.

Gear Antiretraction. In order to operate the landing gear on most of today's modern aircraft, only one manual operation must be performed: to move the gear control handle to either the gear UP position or the gear DN position. In a properly operating landing gear system, everything else is automatic.

To prevent the accidental collapsing of the landing gear while the aircraft is on the ground, most aircraft have some type of antiretraction device. First of all let's see why this device is necessary. Let's say that an aircraft is at the end of the runway ready for takeoff. The landing gear lever is down, the engines are running and hydraulic pressure available to all the subsystems including the landing gear system. Now let's say the

pilot accidentally drops his check sheet on the floor—just below the landing gear lever. He reaches down to pick it up and without knowing it moves the landing gear lever to the UP position. With both electrical and hydraulic power available, the landing gear collapses. The aircraft engineers needed to come up with a way to avoid this problem. They decided that since the aircraft struts are compressed while the aircraft is on the ground and extended in flight, they could install a switch that would prevent accidental gear retraction. This switch has been called many names: *touch down*, *safety* and *scissors*, just to name a few. Basically it opens the electrical circuit to the landing gear control valve—at least until the aircraft is airborne. Even if the landing gear lever is accidentally moved from DOWN to UP while the aircraft is on the ground, the safety switch prevents the gear from retracting. Another way of preventing the landing gear from retracting is to install a lock on the landing gear lever itself. Figure 2-3, shows a simple antiretraction electrical circuit for this lock. Notice that power can flow from the 28V bus through the solenoid, safety switch, and then to ground. The lockpin is extended by spring tension and retracted whenever the solenoid is energized. The landing gear control handle cannot be positioned unless the lockpin is moved out of the way. When the strut is compressed (the aircraft is on the ground), the safety switch is open and the spring forces the lockpin toward the control handle. As the weight of the aircraft leaves the struts during takeoff, the safety switch closes to complete the electrical circuit. The solenoid energizes and unlocks (pulls) the lockpin away from the control handle allowing the pilot to position it to raise the gear. Now ask yourself what will happen when the antiretraction electrical circuit should malfunction or you want to move the landing gear control handle without electrical power. As you can see, the spring forces the locking pin toward the control handle to prevent the handle from moving. The engineers of this aircraft thought this might happen, so they installed a lock release finger latch shown in figure 2-4. By pulling the lock release finger latch down, it compresses the spring behind the lockpin and allows the landing gear control lever to be positioned.

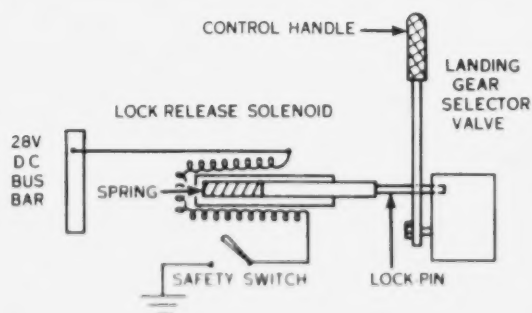


Figure 2-3. Simple antiretraction circuit.

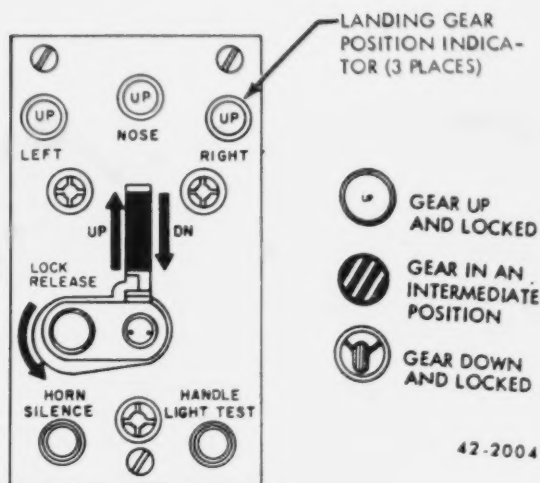


Figure 2-4. Landing gear control panel.

Exercises (608):

1. Why is the antiretraction device installed on aircraft?
2. If the gear is in the air, in what position is the lockpin on the antiretraction device?
3. When the aircraft is on the ground, is the antiretraction electrical circuit complete or open?
4. If you wanted to raise the landing gear lever while the aircraft is on the ground, what must you do?

609. Specify warning indications relevant to the operation of the landing gear position and warning system.

Position Indicators. Several designs of gear position indicators are available. One type consists of three green lights that burn when the gear is down and locked. Any other time, the lights are out. A second type uses electrically operated selsyn indicators that show a picture of the gear position (see fig. 2-4). When any gear is down and locked, a picture of a wheel appears in its indicator window. When any gear is up and locked, the word "UP" appears in the corresponding window. When any gear is neither locked up nor down, a picture of a barber pole appears in the window.

Gear Warning Devices. Warning devices usually consist of a warning horn and a red warning light located in or near the landing gear control handle. The warning light will come on whenever any gear is between the DOWN or UP and LOCKED position. The warning horn will come on whenever the pilot forgets to lower the gear during landing procedures. Depending on the type of aircraft, there are several situations that could cause the warning horn to sound—the throttles retarded, flaps lowered, or air speed too slow to maintain controlled flight.

This tells the pilot to either lower his gear for landing or increase his air speed. If the pilot decides that he doesn't want to do either of these things, he can push the warning horn silence button that silences the warning horn.

Landing Gear Warning System Operation. Now that you are familiar with the units in the warning system, let's see how it works. Let's start with what the pilot sees as he is taking off.

During takeoff, all three position indicators should show a picture of a wheel, and the warning light should be out. Shortly after takeoff, the pilot places the landing gear control lever in the UP position. As the first gear breaks away from its DOWN and LOCKED position, the position indicator moves from the picture of the wheel to the barber pole position. The red warning light also comes on. When the gear gets to the full UP position, it positions the position indicator from barber pole to UP. The red warning light goes off when the last gear is up and all the doors are closed.

When the pilot decides to land, this is what happens. After slowing down to where the slipstream will not do structural damage, he can lower the gear. Up to this time, he should not have any warning light indication, and the position indicator should indicate UP. He places the landing gear control handle to the DOWN position, and the gear begins to move downward. The red warning light will glow when the first wheel well door is opened, and the gear position indicator will move from the UP position to a barber pole position. These two items indicate to the pilot that the gear is unsafe. As each gear locks down, the position indicators will show a wheel. When all three of the gears lock down, the red warning light automatically goes off, allowing the pilot to know it is safe to land.

Exercises (609):

The following questions are referenced to a landing gear warning system that uses a selsyn position indicator.

1. If the gear is between full UP and full DOWN, what position is shown on the position indicator?
2. When will the warning horn come on?

3. How can the warning horn be silenced?
4. When is the red warning light on?
5. The pilot just placed the landing gear handle down, the left main gear locked down, but the right main gear stayed locked in place, and the nose gear is hanging between the full UP and full DOWN position. What indications will the pilot receive to show that his gear are unsafe?

610. Specify the constructional/operational features of a large aircraft landing gear system.

Large Aircraft Landing Gear System. The landing gear system we shall talk about has four main gears that are hydraulic motor driven through a gear box in order to raise and lower the gear. It also has a nose gear strut that is raised and lowered by an actuating cylinder.

The main gear system as shown in foldout 3 consists of four wheels. Each wheel has a separate strut. The struts are attached to jackscrews that are connected to a gear box for each pair of struts. A hydraulic motor attached to each gear box raises or lowers the gear. The hydraulic system supplies fluid under pressure through a landing gear control valve to each of the two landing gear hydraulic motors.

A one-way flow regulator in each line controls the flow of hydraulic fluid from the motor to return. Note that a controllable restrictor valve is in the up line. Through a bellcrank, a lever arm on top of each main landing gear front strut mechanically actuates this controllable restrictor valve just before the gear reaches its fully retracted position. This action closes the valve opening so that it becomes a small orifice. As a result, gear retraction for the final travel is slowed. The shuttle valve is installed to direct the pressure to the spring loaded brake attached to each gear box. The brake lock holds the landing gear in the UP position until the operator releases it, either by hydraulic pressure or by mechanical means. When the airplane is on the ground, a friction washer on each jackscrew (not shown) assembly serves as a downlock. As the main gear extends and retracts, mechanical linkage between the aft main landing gear struts and the doors (not shown) causes the door to open and close.

The nose gear consists of a single strut that is raised and lowered by a hydraulic actuating cylinder. The nose gear is locked in the DOWN position by an internal lock built into the actuating cylinder itself.

When the nose gear is up, it is held in the UP position by an uplock cylinder.

A two-way flow regulator in the up actuation line, upstream of the nose landing gear actuating cylinder, restricts the flow of hydraulic fluid to and from the cylinder. A shuttle valve connects the pressure down line to the emergency system pressure. The emergency extension valve is connected to the emergency hydraulic system (hand pump) to lower the nose gear in emergency.

Normal gear retraction. Assume that the pilot has just taken off, and he places the landing gear control handle in the UP position. As long as the sequence switches on any of the gears are as shown in foldout 3, the selector valve can be energized, because the ground for the up solenoid is made through these switches. With the solenoid energized, the selector valve is positioned to admit hydraulic pressure to the up lines. As pressure flows to the nose gear actuator, it raises the nose gear. Also notice that the pressure is available to the nose gear uplock actuator. As the nose gear reaches the UP position, the uplock locks the gear in the UP position. The ground in the uplock switch will be broken when the uplock is completely locked. Notice that the solenoid operated valve still has a complete ground through the other main gear sequence switches. At the same time that pressure was available to the nose gear, it was also available to the main gear. Notice that the pressure flows through a shuttle valve to the gear box brake. The pressure releases the brake. Now notice that pressure flows to the landing gear motor that turns the gear box to retract the gear. When the main gears are all the way up, the switches are broken and the selector valve is deenergized. When this happens, the gear box brake will lock the gear in the UP position.

Normal gear extension. To lower the gear, the procedures are basically the same as the retraction. The landing gear lever is placed in the DOWN position, but notice that the power goes directly to the control valve and to ground. When this happens, the selector valve is positioned as shown in foldout 4. Pressure is available to release the nose gear uplock and push the nose gear to the DOWN position. Pressure is also available to release the brake on the main gear, which allows the hydraulic motor to extend the gear.

Emergency main gear extension. Emergency methods of actuating the main landing gear mechanically or manually are accomplished by engaging the yellow emergency handles, two extension stub shafts, and two handcranks.

To free the mechanism and prevent damage to equipment and personnel, deplete all hydraulic pressure before actuating the emergency system. The emergency engaging handles are connected by cables to their respective gearbox assembly. Pulling an emergency engaging handle releases the gear brake mechanism and engages the manual extension and retraction gears. A handcrank is then used to operate the appropriate extension stub shaft. The shaft is connected

by mechanical linkage to the gearbox assembly that drives the screwjacks.

Emergency extension of nose gear. To lower the nose gear in emergency, the NLG emergency extension valve must be placed in the EMERGENCY position. When the selector valve is in this position, emergency pressure may be used to unlock the nose gear uplock. When this happens, the nose gear free falls, but may not lock down completely. In order to insure that the nose gear is locked down, the emergency pressure is also sent to the extend side of the nose gear actuator. When the gear is all the way down, the down lock in the nose gear actuator will lock the gear down.

Exercises (610):

1. When the landing gear control lever is placed in the DOWN position, does it matter what position the sequence switches are in? Explain.
2. What units raise and lower the main landing gear during normal operation?
3. What unit will lock the main gear in the UP position during normal operation?
4. How is the main landing gear operated when no hydraulic pressure is available?
5. What precaution must you take before extending the main gear by emergency procedures?
6. How is the nose gear locked in the UP and DOWN positions?
7. How is the nose gear uplock released when the normal hydraulic system is inoperative?
8. What unit in the nose gear system restricts the flow of fluid to and from the gear actuating cylinder?
9. What unit in the main landing gear system directs pressure to the spring loaded brake attached to each gear box?

10. In the nose landing gear system, what unit connects the pressure down line to the emergency system pressure?

611. Cite the normal and emergency operational characteristics of a fighter-type aircraft landing gear system.

Fighter Aircraft Landing Gear System. The main landing gear system, as shown on foldout 5, includes the mechanical units of the gear, a hydraulic system for normal extension and retraction, a pneumatic system for emergency extension, and an electrical system for gear control and position indication. Let's discuss the operation of the landing gear system.

Operation. For normal operation of the system, electrical power and hydraulic power must be applied.

Retraction cycle. Retraction of the landing gear is initiated by placing the landing gear control handle in the GEAR UP position. To energize the gear up solenoid of the landing gear selector valve, 28-volt DC electrical power follows a circuit through the control switch (in control handle), the main gear scissors switches, the nose gear limit switch, and the main gear inboard door close limit switch. Energizing the valve directs hydraulic fluid under pressure from the hydraulic system to the gear up side of the landing gear hydraulic system. At the same time, the gear down side of the system is connected to the hydraulic system return.

The hydraulic fluid pressure directed to the gear up side of the landing gear hydraulic system unlocks the integral down locks (locks that are built internally in the actuator) of the nose gear drag brace actuator to begin gear retraction. As the down limit switches on each actuator break contact, the landing gear warning light illuminates, and the landing gear indicators show barber poles. As each main gear is pulled up by the actuator, the retracting motion causes the shrink mechanism to operate and compress the shock strut.

As the main gear strut reaches several degrees from the UP position a pin on the strut fork engages the uplock hook on the uplock support fitting and causes the hook to rotate. The rotation actuates the hydraulic sequence valve and allows hydraulic fluid under pressure to flow to the uplock actuator. The actuator moves the hook that raises the gear to the UP AND LOCKED position. Hydraulic fluid is directed by the sequence valve to the inboard door actuator through a restrictor. The restrictor allows the inboard door operation to lag behind the uplock and insures correct door overlap. The outboard door is closed mechanically by a link between the strut and the door. The inboard door mechanism actuates a limit switch and causes the indicators for the main landing gear to show the UP AND LOCKED status.

When the nose gear strut reaches a position near the uplock yoke, a roller on the drag brace actuator engages the arm on the uplock sequence valve. Actuation of the sequence valve allows hydraulic fluid under pressure to flow to the uplock actuator that actuates the uplock mechanism. The uplock mechanism raises and locks the strut in the UP position and closes and locks the aft door by means of mechanical linkage. As the gear reaches the UP AND LOCKED position, the nose gear up limit switch and the main gear inboard door close limit switches are actuated. Actuation of the switches deenergizes the selector valve solenoid to relieve hydraulic pressure to the gear up side of the system. Actuation of the switches also causes the warning light in the control handle to go off and the position indicators to show UP.

Extension cycle. The extension cycle of the landing gear is essentially the reverse of the retraction cycle. Placing the landing gear control handle to the GEAR DOWN position energizes the gear down solenoid of the landing gear selector valve. This valve directs hydraulic fluid under pressure to the gear down side of the landing gear hydraulic system and connects the gear up side of the system to return.

On the main landing gear, hydraulic fluid pressure is directed simultaneously to the side brace actuator and the inboard door actuator. The side brace and uplock actuation is retarded by restrictors in the hydraulic system return lines. The inboard door opens first. When the door opens, the door close limit switch is actuated, the indicator in the forward cockpit shows a barber pole indication, and the landing gear warning light comes on. The motion of the side brace actuator is also retarded initially by the piston covering the inlet port to reduce port area. Reduction of the port area allows the uplock mechanism to unlock the strut before there is appreciable motion of the gear. As the side brace actuator locks into the DOWN position, the down limit switch causes the gear position indicator to show a DOWN AND LOCKED position.

During the nose gear extension cycle, hydraulic pressure is applied simultaneously to the gear down sides of the drag brace actuator and to the uplock actuator. Partial coverage of the drag brace actuator pressure port by the piston allows the uplock mechanism to operate first. When the uplock mechanism is forced overcenter by the lock actuator, allowing the gear to extend, the up limit switch is actuated, causing the indicators to show barber poles. As the drag brace actuator locks in the DOWN position, it actuates the nose gear down limit switch, causing the indicator to show a DOWN AND LOCKED position. When all three switches are actuated, the landing gear warning light goes out.

When the gear is compressed by the weight of the aircraft, the scissors switches are actuated. Actuation of the switches breaks the electrical circuit from the landing gear control handles to the gear up solenoid of the landing gear selector valve. This prevents the valve from changing to the UP position, even though the landing gear control handle is moved to the GEAR

UP position. Thus, the gear cannot be raised when the weight of the aircraft is on the gear.

Emergency extension. When the landing gear control handle in either cockpit is pulled aft, the landing gear emergency pneumatic selector valve opens. This allows compressed air from the emergency air bottles to discharge through the pneumatic lines and shuttle valves to the landing gear system actuators. The high-pressure air actuates the pressure-operated dump valve to dump all hydraulic fluid from the up side of the system overboard. Emergency air pressure is applied to the main gear uplock actuators, main gear side brace actuators, main gear inboard door actuators, nose gear uplock actuator, and nose gear drag brace actuator. Then, the landing gear extends as in normal sequence. The warning light and position indicators also operate as in normal sequence.

Exercises (611):

1. What prevents the gear from retracting while the aircraft is on the ground?
2. How are the gear doors sequenced?
3. How are the gears locked down?
4. When all the gears are fully up and locked, is the selector valve energized or deenergized?
5. When the emergency system is actuated, what happens to the fluid in the landing gear actuator? Explain.
6. During the nose gear extension cycle, to what two areas is hydraulic pressure applied simultaneously?
7. During the nose gear retracting cycle, what component raises and locks the strut in the UP position and closes and locks the aft door by means of mechanical linkage?
8. During the retraction of the main gear, a pin on the strut lock engages the uplock hook and causes it to rotate. What happens as the uplock hook rotates?

9. When will the landing gear warning light illuminate?
 10. During main gear retraction, what causes the uplock hook to rotate?
 11. During main gear retraction, what unit allows the inboard door operation to lag behind uplock?
 12. During nose gear retraction, how is the aft door closed and locked?
612. State the purpose of an arresting hook system and specify its constructional and operational features.

Arresting Gear System. The arresting gear system, shown in figure 2-5, selected for this discussion, is used to halt the forward motion of the aircraft if wheel brakes, speed brakes, and drag chute fail to do so. When extended, the hook in the arresting gear system will engage a cable barrier at the end of the runway. This arresting hook is held against the runway by an air-oil pressurized vertical damper cylinder and dash pot and may be retracted by pressurized hydraulic fluid. Barrier cables are designed to bring aircraft to a gradual stop. Since this is usually the last possible means of stopping an aircraft, it is extremely important to keep the arresting gear system free of troubles.

Operation. The major components in the arresting gear system are shown in figure 2-5. The main unit in this system is the arresting hook, which is located on the underside of the aft fuselage. The hook is pivoted at the forward end, allowing up, down, and sideways motion. Raising and lowering of the hook is controlled by a lever in the forward cockpit. The lever controls the arresting hook uplatch mechanism through mechanical linkage and the control cable. Also, the lever operates an arresting gear control switch to electrically energize or deenergize the solenoid on the selector valve. The selector valve controls the flow of hydraulic fluid to the vertical damper cylinder. Fluid going to and from the vertical damper cylinder is routed through the surge damper. The surge damper prevents hydraulic pressure surges from affecting arresting gear retraction. The hook point is a replaceable unit. The air pressure gage registers the nitrogen charge in the vertical damper cylinder.

Thus far we have talked about the purpose of individual components. Now, let's see how these components operate together to retract the arresting hook.

Figure 2-5 shows the arresting gear system components schematically with the control lever in the HOOK UP position and the hook retracting. When the control lever is moved to the HOOK UP position as shown by the black arrows, the selector valve control switch is activated and energizes a solenoid-operated selector valve. Energizing the solenoid on the selector valve directs hydraulic system pressure by way of the surge damper, through the two-way restrictor, and into the bottom side of the vertical damper cylinder. The hydraulic pressure, acting on the vertical damper cylinder piston, moves the piston up and increases the air-oil pressure above the piston. The upward movement of the vertical damper cylinder piston raises (retracts) the arresting hook.

The arresting hook time delay relay is wired through the hook up limit switch. After an elapse of 1.1 seconds from the time the arresting hook contacts the hook up limit switch, the time delay relay deenergizes the selector valve, relieving hydraulic pressure from the bottom side of the vertical damper cylinder through the surge damper and back to the utility system return line. With the hydraulic pressure relieved, the spring-loaded uplatch mechanism locks the arresting hook in the raised (retracted) position.

Now, let us see how the arresting hook is extended. Movement of the control lever to the HOOK DOWN position removes tension from the arresting hook control cable, releasing the spring-loaded uplatch mechanism.

Also, this movement of the control lever opens a circuit in the selector valve control switch. Opening this circuit causes the solenoid-operated selector valve to spring open. This allows trapped hydraulic fluid in the bottom of the vertical damper cylinder to free flow through the two-way restrictor, the surge damper, and then into a return line back to the utility hydraulic system. After the trapped hydraulic fluid is released, the air-oil pressure in the top of the vertical damper cylinder and the weight of the arresting hook cause the hook to extend. The speed at which the hook extends is controlled by the two-way restrictor. In addition, movement of the control lever to the HOOK DOWN position releases the hook up limit switch, which illuminates the warning light in the control lever.

Exercises (612):

1. What is the purpose of the arrestor hook?
2. What is the purpose of the arresting gear selector valve?
3. How is the hook held in the UP position?

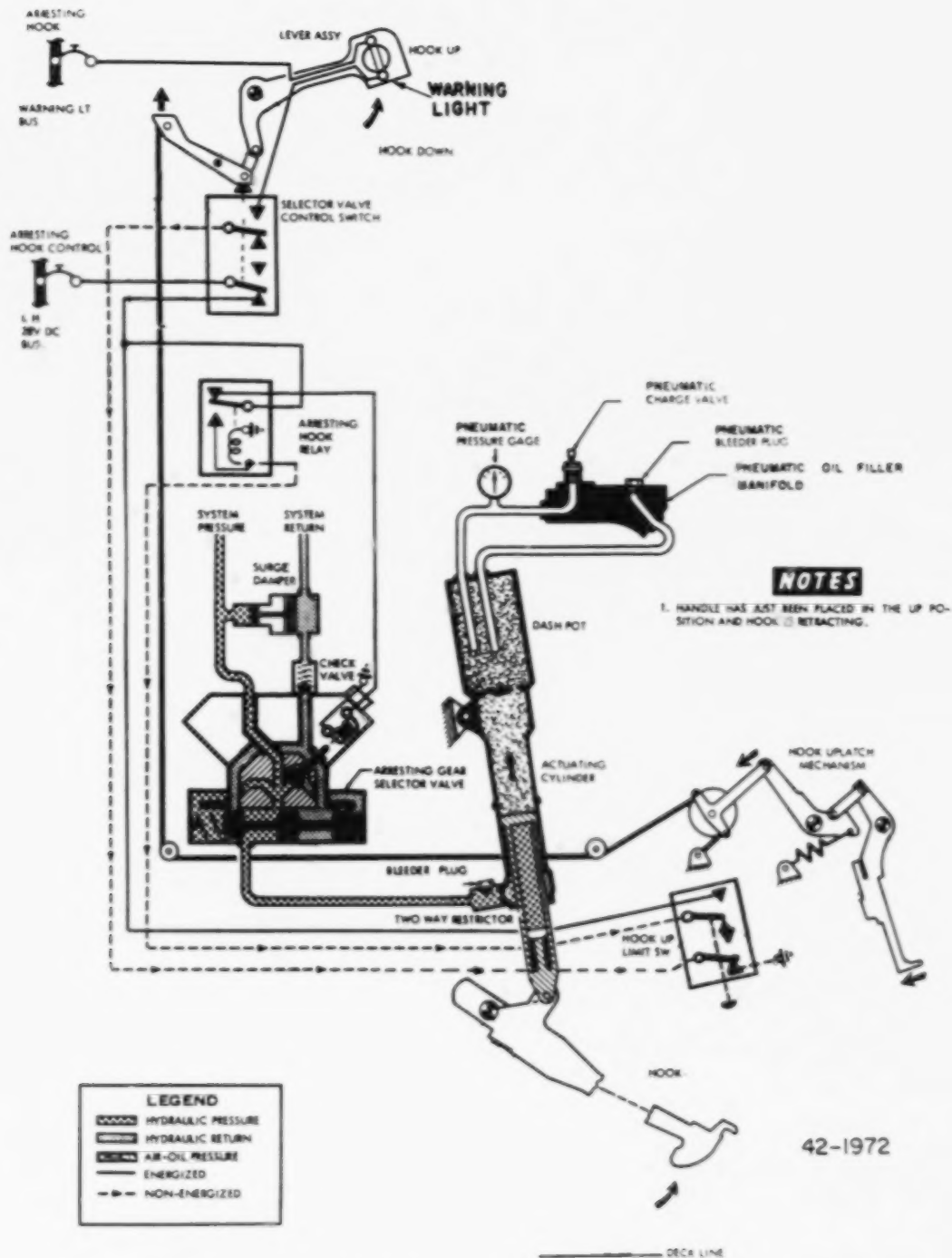


Figure 2-5. Arresting (tail hook) gear.

4. What causes the hook to extend when the hook is released from the uplock?
5. What unit prevents hydraulic pressure surges from affecting arresting gear retraction?
6. How is the spring loaded uplock mechanism released?
7. What controls the speed at which the arresting hook extends?
8. How long will it take before the selector valve is energized and relieves hydraulic pressure from the bottom of the vertical damper cylinder?

2-2. Nosewheel Steering

The use of nosewheel steering and damping systems makes it possible to steer aircraft in confined areas without creating the usual disturbance or problems that stem from accelerating the engines or applying the brakes. The resultant longer life of engines and brake linings on aircraft using nose steering and damping systems justifies their use.

Pressure from the aircraft hydraulic system is used to turn the nosewheel either left or right, depending on the pilot's selection. Also, the type of aircraft determines if the system is operated manually (mechanically) or electrically. In this section we talk about the construction and operation of these two types of nose-wheel steering systems.

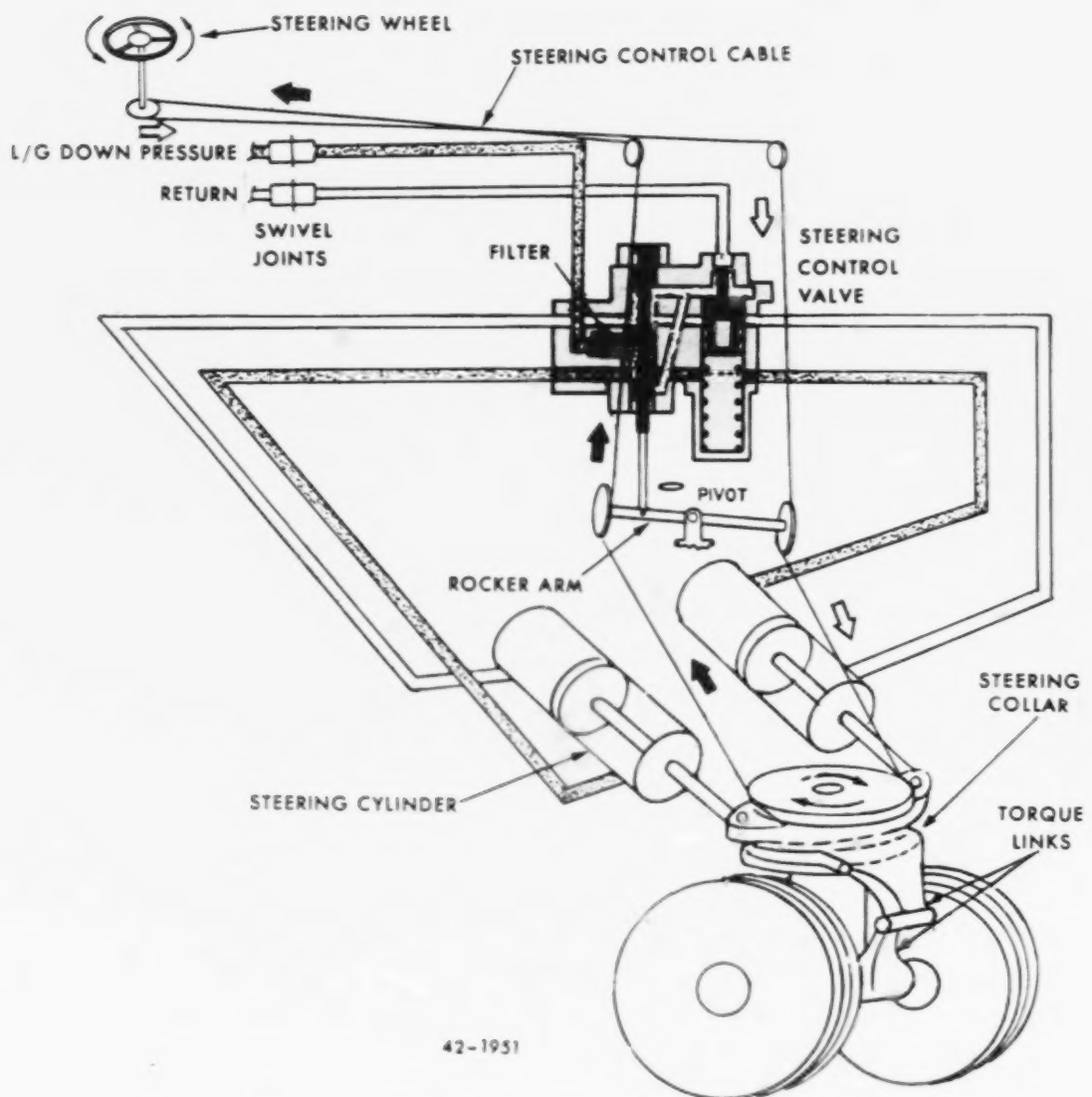
613. Specify the constructional/operational features of a cable-operated nosewheel steering system.

Cable- (Mechanically) Operated Nosewheel Steering System. Most larger type aircraft use a cable-operated steering system as pictured in figure 2-6. The steering wheel is cable-connected to a steering collar on the strut. Notice that the rocker arm has pulleys for the cable and is able to pivot and position a metering valve in the steering control valve. The steering actuators can rotate the nose strut steering collar a specific amount, depending on the aircraft involved. Let's see what happens when the steering wheel is turned. At the beginning of a left turn, the cables with the black arrows become tight, and the cables with

the white arrows become slack. This action changes the tension on the metering valve rocker arm, causing it to pivot. When the metering valve rocker arm pivots, the metering valve mechanism is positioned to send pressure to the steering actuators to rotate the nose-wheel strut assembly. The steering cylinders are double-acting hydraulic actuators. The cylinder barrels are designed to remain stationary, but the piston rods, attached to the steering collar, are movable. The steering collar is attached to the upper torque link of the strut. The lower torque link is attached to the strut piston. Both torque links are jointed together to provide a mechanical linkage between the steering collar and the lower portion of the strut. Normally, whenever the aircraft is to be towed, the upper and lower torque links can be separated. If the torque links are not separated during towing, the fluid in the steering cylinders would have to transfer from one cylinder to the other. With the torque links disconnected, just the lower portion of the aircraft strut rotates. As the steering cylinders move, notice that the steering collar also moves in a direction that tends to equalize the tension on the cables. This is commonly called a followup action and allows the metering valve to return to center, which stops fluid pressure to the steering actuators once the desired amount of travel has been acquired. The return fluid from the cylinders must flow through the compensator of the steering metering valve. The compensator keeps a certain amount of back pressure in the lines for shimmy damper action.

Exercises (613):

1. If the control wheel is rotated clockwise, which direction will the gear move?
2. When towing the aircraft, why should the torque links be disconnected?
3. What repositions the selector valve to neutral when the gear reaches a desired position?
4. What parts of the steering cylinder are stationary and what parts are movable?
5. What portion of the strut is attached to the strut piston?



42-1951

Figure 2-6. Cable operated nose wheel steering.

6. What portion of the steering system is able to pivot and position a metering valve in the steering control valve?

614. Cite the function of the components and specify the operational characteristics of an electrically operated nosewheel steering system.

Electrical Nosewheel Steering System Construction.
As a mechanic responsible for maintaining the nose

gear steering system, you must become familiar with each component. Each electrically operated nosewheel steering system varies in its construction, but you should be able to apply the principles presented here to each system you encounter. Let's begin our discussion with the function of the nose gear steering components. Refer to foldout 6 (found in a separate inclosure) as we talk about the components and system operation.

The command potentiometer is attached mechanically to the rudder pedals. When the rudder pedals are in any position other than NEUTRAL, a signal is produced that is fed into the differential amplifier

(control box). Notice that the potentiometer consists of a wiper arm on a resistance strip.

The followup potentiometer is attached to the power steering unit. The followup indicates the position of the power unit.

The selector valve is a remotely controlled, three-way, two-position single-solenoid operated valve used to direct utility hydraulic pressure to the steering system. Notice the two-way restrictor just below the selector valve. This valve is installed in the system to replenish any fluid lost when the selector valve is de-energized.

The power unit is a vane hydraulic actuator mounted on the nose strut and geared to the strut torque collar. It performs both steering and shimmy damping. A bypass allows hydraulic pressure to flow to the proper side of the steering unit as directed by the servo valve. When the system is deenergized, the bypass valve shifts to trap hydraulic fluid in a channel that connects the hydraulic motor with two one-way restrictors to dampen a wheel shimmy.

When energized, the servo valve sends fluid to one side or the other of the power steering unit. When the power steering unit reaches the desired position, the servo valve is positioned to NEUTRAL, thus blocking the pressure in either side of the power steering unit.

The compensator maintains approximately 300 psi back pressure in the steering unit to prevent cavitation of the vane motor and dampen shimmy when the steering system is not energized. The compensator housing contains two loaded springs that seat against a piston and sleeve and a spring-loaded poppet. Fluid flow is in one direction only: from the power steering unit to return. Return flow from the steering unit displaces the piston and opens the poppet. When the steering unit is deenergized, spring pressure returns the piston and closes the poppet to build up the back pressure in the power unit.

Operation. The nose gear steering system is energized by depressing the nose gear switch on control stick grip. Before the system can be energized, the gear must be down and locked; and the main landing gear struts must be compressed.

When the system is energized, movement of the rudder pedals forward or aft controls the output voltage of the nose gear (input) steering potentiometer. This potentiometer supplies voltage to a differential amplifier in the nose gear steering control unit. The output of the differential amplifier determines which coil in the nose gear steering servo valve receives the most current. The servo valve directs hydraulic fluid to the power unit to turn the wheels right or left. A followup potentiometer is geared to the power unit. The followup potentiometer sends a signal to the differential amplifier. If an error signal exists between the followup and command potentiometers, the differential amplifier sends current to the servo valve. In turn, the servo valve moves to direct hydraulic fluid to the power unit. In turn, the power unit moves the nosewheels to reduce the error. When the error is corrected, the nosewheels stop at the desired angle of

turn. If an open or short circuit occurs in one of the inputs to the control unit, a failure detection network (inside the control box) detects the failure and de-energizes the solenoid in the nose gear steering selector valve. When the solenoid is deenergized, hydraulic pressure is shut off to the steering system. To resume normal operation of the system, the steering switch must be recycled.

Right turn. When the right rudder pedal is moved forward to execute a right turn, the command potentiometer (mechanically linked to the rudder pedal torque tube) sends an increased voltage signal to the differential amplifier. In turn, the amplifier increases the voltage to the right turn coil in the servo valve. The servo valve piston moves and ports hydraulic fluid pressure to the vane motor in the power unit to turn the nosewheels right. As the wheels turn, the wiper arm on the followup potentiometer sends an increased voltage signal to the differential amplifier. When voltage from the followup potentiometer equals voltage from the command potentiometer, the signal is zero and current equalizes in the left and right turn coils of the servo valve. The servo valve then holds the wheels at the desired degree of right turn.

Left turn. When the left rudder pedal is moved forward to execute a left turn, the command potentiometer sends an increased voltage signal to the differential amplifier. The amplifier increases the voltage to the left turn coil in the servo valve. The servo valve piston moves and ports hydraulic fluid pressure to the vane motor in the power unit to turn the nosewheels left. As the wheels turn, the wiper arm on the followup potentiometer sends an increased voltage signal to the differential amplifier. When the voltage from the followup potentiometer equals voltage from the command potentiometer, the signal is zero and current equalizes in the left and right turn coils at the servo valve. The servo valve then holds the wheels at the desired degree of left turn.

Failure detection. The failure detection circuit detects a short, an open, or intermittent signal from the command potentiometer, followup potentiometer, and servo valve. Depressing the nose gear steering switch provides voltage to the control unit power supply and failure detection circuit. If signals from the command potentiometer, followup potentiometer, or servo valve become shorted or open, negative voltage is applied to the detector circuit. In turn, the detection circuit opens the ground circuit to the selector valve solenoid to stop hydraulic fluid to the system.

Exercises (614):

1. What two components control the position of the servo valve?
2. If the electrical system should fail, what will happen?

3. What is the function of the compensator?
4. When the rudder pedals are moved, what do they position?
5. What happens to the servo valve when the signal voltage in the left and right servo valve turn coils is zero?

Look at foldout 6 and answer the following questions.

6. Before the nose wheel steering system could be energized, specify the three items that must be properly positioned.
7. What item energizes the nosewheel steering system?
8. What unit, when the system is deenergized, will shift positions to trap hydraulic fluid in a channel that connects the steering unit with two one-way restrictors?

2-3. Brake Systems

The purpose of a wheel brake is to bring a rapidly moving aircraft to a stop during ground roll. It does this by changing the energy of movement into heat energy through the friction developed in the brakes. It also can be used to park the aircraft.

A feature found in high performance aircraft braking systems is skid control or antiskid protection. This is an important system because if a wheel goes into a skid, its braking value is greatly reduced. The main components of the system consist of skid control generators (detectors), a skid control box, two skid control valves, a skid control switch, a warning lamp, and an electrical control harness.

In this section we will talk about the construction and operation of the two brake systems. The difference between the two lies in the emergency braking system and an antispin system.

615. Specify constructional/operational features of a brake system that induces antiskid and an electrically controlled hydraulically operated emergency system.

Brake System. The braking system provides normal, emergency, and parking brakes. Both the normal and emergency systems are operated by the pilot's and copilot's rudder pedals. The components usually found in a brake system are the power brake control valve, brake assembly, shuttle valves, accumulators, and the shutoff valve, to name just a few.

Antiskid System. The antiskid system prevents wheel locking and skidding. The components in the antiskid system are: skid detectors, antiskid control valves, and various relay circuits. Besides the normal skid control circuit, the antiskid system may have such circuits as the (1) locked wheel skid control, (2) touchdown protection, and (3) fail-safe protection circuit. A brief description of each of these circuits is covered below.

Locked wheel skid control. The locked wheel skid control causes the brake to be fully released when its wheel locks. A locked wheel easily occurs on a patch of ice due to lack of tire friction with the surface. It will occur if the normal skid control does not prevent the wheel from reaching a full skid.

Touchdown protection. The touchdown protection circuit prevents the brakes from being applied during the landing approach *even if the brake pedals are depressed*. This prevents the wheels from being locked when they contact the runway.

Fail-safe protection. The fail-safe protection circuit monitors operation of the skid control system. It automatically returns the brake system to full manual in case of system failure. It also turns on a warning light.

Brake System Operation. Regardless of the brake and antiskid system installed on the aircraft, the operation is very similar. Refer to foldout 7 (found in a separate inclosure) as we discuss brake and antiskid operation.

During operation, downward pressure on the rudder pedal moves the upper brake lever. This movement is passed to the brake control valve. The brake control valve directs hydraulic pressure to the brakes. A normal or emergency brake selector valve determines whether the utility hydraulic system or the auxiliary system pressure is to be used. The brake selector switch selects either normal or emergency operation of the system. When the switch is placed in NORM, the emergency selector valve is energized, and the emergency part of the system is connected to the return. Also, the normal brake selector valve is deenergized, permitting utility hydraulic pressure to be transmitted to the brakes. When the brake selector switch is placed in EMER, the opposite condition exists. Utility pressure is blocked, and the normal brake system fluid is routed to return. Auxiliary pressure then controls brake operation. Shuttle valves at the brake assemblies block off the pressure from the system not in use. If DC power to the brake selector valves fails, both valves are positioned to allow operation from either the utility or auxiliary hydraulic system. The auxiliary hydraulic system handpump can be used for emergency braking, but you must hold the brake pedal

down while the handpump is being operated. If you pump the brake pedal, you will bleed away pressure faster than the handpump can be operated. If a wheel tries to skid during braking operations, the antiskid system activates.

The antiskid system works through a brake pressure releasing valve that is controlled by a skid detection element in each wheel. This element detects nonrotation and/or a rapid change in wheel speed. The system is controlled by relays that control the antiskid valve. For example, there are no brakes for 2 seconds or until both locked-wheel detection relays are energized by wheel speed above 15 knots. When the detection relays are energized, a circuit is completed that actuates relays in the safe-braking control boxes. These relays provide remote control of the antiskid valve. The antiskid valve controls the speed by releasing and reapplying brake pressure as the wheels depart from and return to nonskid speeds. The detector speed-sensing circuit causes the brakes to be released on any pair of wheels that has a tendency to begin skidding. When the aircraft has stopped, the speed-sensing circuit becomes ineffective and the brakes remain on.

Included in the antiskid system is a fail-safe circuit. This circuit keeps the brakes from releasing too long because of antiskid action. If the brakes release too long, there might be insufficient runway for braking to a safe stop. The fail-safe circuit is controlled by a slow release fail-safe relay. This relay prevents continuous release of brake pressure for more than 3.5 seconds. Also, it automatically returns the brake system to normal in case the antiskid system fails.

Exercises (615):

1. Which hydraulic system powers the emergency brakes?
2. What controls the operation of the fail-safe circuit?
3. When the brake selector switch is placed in normal, what brake selector valve is energized and what brake selector valve is deenergized?
4. What unit directs fluid pressure to the brakes?
5. What happens if DC power to the brake selector valve fails?
6. What does the brake skid detection element detect?
7. How are the antiskid valves controlled?
8. What circuit prevents the brakes from being applied during a landing approach?
9. Through what valve does the antiskid system work?
10. Why must you hold the brake pedal down while the auxiliary hydraulic system handpump is being used?

616. Cite the constructional/operational features of a brake system that includes an antiskid system, an antispin system, and a mechanically controlled hydraulically operated emergency system.

Brake Control Units. The brake control units, fold-out 8 found in a separate cover, have two valving portions: one for normal braking and one for emergency braking. An accumulator stores hydraulic fluid under pressure for emergency braking. If utility hydraulic pressure fails, a manually operated emergency brake valve that can be actuated by a T-handle in either cockpit directs fluid from the accumulator to the emergency portion of the brake control valve.

Antiskid System. The antiskid portion of the system consists of an exciter ring and sensor for each of the main gear wheels, a control valve, an on-off switch, disengage switches on the forward and aft control stick, and a warning light.

Antispin System. The antispin system receives hydraulic pressure from the landing gear up line. This pressure is metered through restrictors to the brakes to stop wheel rotation while the gear is being retracted.

Operation. Normal braking is accomplished by depressing the rudder-brake pedals in either the forward or aft cockpit. The antiskid system is turned on or off by a switch located on the pilot's left utility panel. Emergency braking is accomplished by pulling aft on either of the emergency brake handles and depressing the rudderbrake pedals.

Normal braking. During normal braking operation, pressure applied to the brake pedal causes a shift in the piston of the brake control unit. Shifting of the

piston causes the return port to close and the pressure port to open. The size of the opening of the pressure port determines and regulates the amount of hydraulic pressure that flows through the control unit and to the individual brakes.

Metered hydraulic pressure from the brake control unit passes through the deenergized antiskid control valve to the wheel brakes. The force acting upon the brakes slows down or stops wheel rotation. When hydraulic pressure is released, the brakes return to their original position to release the braking force.

Antiskid. When the antiskid system is turned on and aircraft speed is above 15 knots, a AC signal is generated by movement of the exciter ring through the magnetic field of the sensor. The generated emf is detected by the antiskid sensor and sent as an input to the antiskid control box. If neither wheel is skidding when brakes are applied, the output of the skid rate detector in the antiskid control box is negative. Therefore, no signal is sent to the antiskid control valve, and hydraulic pressure to the brakes remains constant. If either wheel starts to skid while the brakes are applied, a signal is sent to the control box. In turn, the control box sends a signal to the antiskid control valve to reduce pressure to the brakes. Thus, any rate-of-change signal received by the antiskid control valve results in a proportional reduction in brake pressure. As the wheel recovers from a skid, the rate-of-change signal disappears and brake pressure increases correspondingly. Locked wheel and skid protection is removed when aircraft speed is less than 15 knots to permit low-speed maneuvers and to allow parking.

Emergency braking. If utility hydraulic pressure fails, emergency braking can be applied by pulling the emergency brake handle. Pulling either handle opens the emergency brake manual valve. When this valve opens, hydraulic fluid, stored under pressure in the accumulator, flows to the emergency ports of the brake control units. The accumulator holds enough fluid under pressure for 11 to 13 brake applications. Emergency operation of the control unit is essentially the same as normal operation. Metered pressure from the brake control unit passes directly to a shuttle valve and enters the brake. Note that during emergency operation, hydraulic fluid does not flow through the antiskid control valve. Therefore, there is no antiskid function during emergency braking.

Antispin. Whenever an aircraft first takes off, the wheels will be still spinning at an extremely fast speed. If the gear handle is placed in the UP position, the fast spinning wheels will enter the wheel wells. To prevent this from happening, some aircraft have installed brake antispin systems. Notice the hydraulic line that is coming from the gear up line. Whenever the gear is raised, pressure in the gear up line will flow through the check valves down to the brakes. With pressure applied to the brake, the wheel will STOP spinning as the gear is raised.

Exercises (616):

1. What system is used to apply the brakes as the gear is retracted?
2. What circuit provides a full pressure release signal to the antiskid control valve when both wheels stop rotating?
3. How is normal braking action accomplished?
4. What determines and regulates the amount of hydraulic pressure that flows through the control unit to the individual brakes?
5. How is emergency braking action accomplished?
6. What is the output of the skid rate detector in the control box when the brakes are applied and neither wheel is skidding?
7. Why is there no antiskid function during emergency braking?
8. From where does the antispin system get its hydraulic fluid for operation?
9. When the antiskid system is turned on, how is an AC signal generated?
10. How much fluid is held by the emergency brake accumulator?
11. When will locked wheel and skid protection be removed from the wheels?

2-4. Inspection, Maintenance, and Operational Checks of Landing Gear Systems

In the early days of aviation, the landing gear system consisted of fixed struts with a simple brake system. The job of the pneumatic specialist, if they had any in those days, would probably have consisted of inspection, removal and replacement of components, and operational checks of the brake system. The pneumatic specialist of today hasn't advanced very much because the job still consists of inspection, removal and replacement of components, and operational checks. The landing gear systems and components, however, have advanced and have become more sophisticated and complex. We now have landing gear systems that retract and extend the struts, brake systems with antiskid and antispin features, and nose-wheel steering. As the requirement for faster and high-flying aircraft increases, the requirement for a more complex landing gear system also increases. This in turn increases the necessity for a superior level of maintenance.

In this section we cover such landing gear systems maintenance areas as inspections, component removal and replacement, and operational checks. It would be impossible in this CDC for us to cover these areas of maintenance on specific systems. We cover what we consider are common maintenance tasks and in some cases use representative examples of maintenance tasks performed on certain aircraft and components.

617. Cite the common inspection requirements of the landing gear and related systems.

Inspection Requirements. The inspection requirements for the landing gear and related systems will differ from one type of aircraft to another. No matter which aircraft you work on, the details of what to inspect and when to inspect are already laid out for you either on inspection workcards or in the -6 TO. What we have done is combine common inspection requirements for the landing gear and related systems.

Landing gear. One of the first things that enters a person's mind when you say "landing gear" is the struts themselves. The struts should be checked for leakage, corrosion, and signs of damage. The struts should also be checked to insure proper servicing. The lines and hoses should be checked for damage or leakage. The various valves in the system should be checked for security of mounting. The actuating cylinder should be checked for leakage, security of mounting, and proper adjustment.

Nosewheel steering. Since the nosewheel steering is confined primarily to the nose strut, you should check the nose strut for any damage. Check the steering units, actuators, and valves for leakage and security of mounting. Check the hydraulic lines for leakage and damage. Any electrical connections should be checked for cuts or broken wires. If the nose wheel steering system is controlled by cables, check the

cables for damage. To insure that they are not broken or cracked, check the cable pulleys.

Brake systems. One of the main items in the brake system is the brake itself. Examine the brake for wear, overheating, corrosion, and leakage. Check the power brake control valve or master cylinder for adjustment, binding, security of mounting, and leakage. Other hydraulic components, such as antiskid valves, shuttle valves, and boosters, should be checked for security of mounting and leakage. Check brake lines and hoses for damage and leakage.

Common inspection items. Besides checking all of the above items in the respective systems, you should also check for missing clamps, nuts, bolts, and washers. Another thing commonly found on inspections is that items are safety wired wrong or not at all. On finding a damaged line you should ask yourself "What could have caused this damage?". Did a rock strike the line, did someone step on it, or is it chaffing another item as the system is operated? Simple removal and replacement of the damaged line is not enough. You could fix the malfunction temporarily, but if the original malfunction is not corrected, it will simply happen again.

Exercises (617):

1. While performing an inspection of landing gear system, you find a line in the wheel well that is chaffed. What should you do?
2. Cite three inspection items for a landing gear actuator cylinder.
3. Name two things electrical connections should be checked for.
4. Cite four items the brake itself would be inspected for.
5. What are the items a power brake control valve would be inspected for?
6. In a cable operated nosewheel steering system, what are the cable pulleys inspected for?

618. From given situations, specify the procedure that was violated during the removal or installation of landing gear components.

Removing Landing Gear Components. Probably you heard about the mechanic who was trying to remove a nose landing gear actuator without having the aircraft jacked. On this particular model of aircraft, the nose gear actuating cylinder was acting as the landing gear downlock. He removed the hydraulic lines and then took the nut and washer off the mount bolt. He tried to take the bolt out that was connecting the actuator to the nose strut. It was extremely difficult to do so. He then took a large hammer and beat the bolt out of the eye bolt that was attached to the strut. As the bolt was forced out of the eye bolt, the nose gear collapsed.

Let's look at another example; but in this case the mechanic had just installed the landing gear control valve. After installing the control valve, he decided to perform an operational check. He jacked the aircraft and applied hydraulic and electrical power. He then raised the control lever in the cockpit to the UP position, but nothing happened. He looked in the wheel well (where the control valve was located) and noticed that the cannon plug on the control valve was left off. Without dropping hydraulic pressure, he went into the wheel well and started screwing the cannon plug onto the control valve. With hydraulic pressure, electrical power, and the landing gear lever still in the UP position, the landing gear retracted. Another thing wrong in this situation was that the mechanic was still in the wheel well when the gear retracted.

These are only two examples of what can happen when technical order procedures are not followed when removing and installing components in the landing gear system. To cover the removal and replacement of all the landing gear components in all the landing gear systems in the Air Force inventory is beyond the scope of this CDC. We encourage you to follow technical order procedure. The steps that follow are general information that can be applied to most aircraft.

1. Assemble all the tools and equipment needed to remove the component.
2. Determine whether the aircraft should be jacked. Some landing gear components do not need the aircraft jacked in order to change them. The TO should indicate this.
3. Depressurize the hydraulic system, and remove electrical power.
4. Make sure that ground safety pins are installed.
5. Disconnect the hydraulic lines and cap or plug the lines. In some cases it may be necessary to tag the lines to indicate to what ports they should be installed.
6. Remove any electrical connections, cannon plugs, quick disconnects or switches.
7. Remove the mount bolts and the component.

Installing Landing Gear Components. Once the landing gear component is removed, if you have the replacement part, you can proceed to install the replacement part. The installation procedure is basically the reverse of removal. The only difference will be

that new O-ring seals should be installed during installation. After installation, the system should be operationally checked to insure proper system operation.

Exercises (618):

Read the following situations and determine what step was violated during the removal or installation of a landing gear component.

1. The mechanic had to stop because he needed a special tool.
2. Fluid was dripping down the mechanics arm when removing the mount bolts.
3. Fluid sprayed out during the removal of the hydraulic lines.
4. The mechanic couldn't figure out which ports the hydraulic lines were supposed to go to during installation of a component.
5. The landing gear started leaking after installation.
6. After the first flight, a landing gear system malfunctioned after a component in the system was removed and installed.

619. Specify equipment and reasons for the procedures for performing an operational check of the landing gear.

Conditions Requiring Operational Check. One method of locating malfunctions in the landing gear system is to perform a gear operational check in which you retract and extend the gear.

There are, of course, several occasions when you should make an operational check. First, you should make an operational check during a periodic inspection of the landing gear system. Second, if you perform maintenance that might affect the landing gear linkage or adjustment (such as changing a shock strut), you should make an operational check to see whether or not you have everything connected and adjusted properly. Third, it may be necessary for you to make an operational check of the landing gear after a hard

landing has been made that could damage the landing gear. You should closely inspect the gear and then make the operational check. Finally, if the pilot, while flying the aircraft, notices some malfunction in the operation of the landing gear system, he may request that an operational check of the gear be performed; then, of course, you would check to locate the trouble.

Equipment. The first action taken when preparing to perform an operational check of the landing gear is to jack the aircraft (using proper jacks and jacking procedures discussed in Volume 2 of this course). The aircraft must be raised high enough to allow the landing gear to safely clear the ground during all operational actions. Two units of powered AGE required to perform a landing gear operational check are:

1. The hydraulic test stand, such as the one discussed in Volume 2, must have the capability of supplying the same volume output and pressure normally delivered by the engine-driven pump. For example, the hydraulic power requirements for the retraction of an aircraft landing gear may be 3,000 psi with a flow rate of 15 gpm.

2. Also, electrical power is required for landing gear operation. Electrical power requirements vary from aircraft to aircraft; however, in most cases, the MD-3 electrical power unit can be used for a landing gear operational check.

Normal procedures. Procedures for an operational check of the landing gear are similar for most aircraft. The procedures given below are representative of a landing gear operational check.

1. After the aircraft is properly jacked, remove the nose gear, main landing gear, and main landing gear inboard doors safetying devices.

2. Apply external electrical and hydraulic power (set the hydraulic power unit, as an example, to 3,000 psi with a flow rate of 15 gpm).

3. After the hydraulic power unit has stabilized and the area has been checked for foreign objects, place the landing gear handle in the UP position. The nose and main landing gear should move smoothly to the UP and LOCKED position, before the inboard landing gear door closes. The landing gear control handle warning light should illuminate when the handle is moved to UP and should extinguish when the gear is UP and LOCKED. Also, the nose and main landing gear position indicators should indicate barber pole while the gear is in transit and should indicate UP when the gear is UP and LOCKED.

4. Place the landing gear control handle in the DOWN position. The nose and main gear should extend smoothly to the DOWN and LOCKED position. Once again, the landing gear control handle warning light should illuminate when the handle is moved to the DOWN position and should go out when the gear is down and locked.

5. After the landing gear has been cycled a minimum of three times (and certified as in proper operating condition), the operational check is complete.

Emergency procedures. Most of today's aircraft have some means of lowering the gear in emergency. It

could consist of just a cable the pilot pulls to release the gear uplocks, or some mechanical means of cranking the gear down. Some systems use an emergency hydraulic pump; others use pneumatic pressure. The procedures for lowering the gear using pneumatic pressure follow:

1. Insure that the pneumatic system is serviced.
2. Raise the gear until it is up and locked.
3. Shut down hydraulic and electrical power.
4. Place a container under the aircraft to catch any hydraulic fluid that might be poured overboard during extension.

5. Next pull the emergency landing gear lever. The gear should lower smoothly and lock down. You can check for leakage of the pneumatic system at this time.

6. Release the air holding the gear down.

NOTE: Any time pneumatic pressure is used, the system must be bled of air before the aircraft is released for flight.

7. Apply hydraulic and electrical power to the aircraft. CAUTION: Be sure to follow technical order procedures precisely at this point.

8. Cycle the gear until the system is clear of air.
9. At this time, secure the aircraft by removing all external power, installing all landing gear and landing gear door safety devices; then lower the aircraft and remove the jacks.

Exercises (619):

1. What are three conditions which require an operational check of the landing gear?
2. What aerospace ground equipment is required to perform an operational check of the landing gear?
3. The hydraulic test stand required to perform an operational check of the landing gear should be adjusted to what volume and pressure?
4. How high off the ground should the aircraft be jacked?
5. After lowering the gear in emergency using pneumatic pressure, what should be done before the aircraft is released?
6. What should the landing gear position indicator show when the landing gear is in transit?

7. You have completed our operational check of the pneumatic emergency landing gear system and have applied hydraulic and electrical power to the aircraft. How long do you cycle the gear through its operation with hydraulic fluid?
8. During a normal operational check, when can the operational check be termed complete?
9. Why must a container be placed under the aircraft before the emergency landing gear system is activated to check gear extension?
10. During the emergency system operational check, one of the procedures is to release the air holding the gear down. When should this be done?

620. Tell why selected steps of servicing a shock strut are needed, and specify general operating principles relative to shock strut servicing.

Shock Strut Servicing. All shock struts are provided with an instruction plate that gives, in a condensed form, instructions relative to the filling of the strut with fluid and air. It is usually attached near the filler inlet and air valve assembly. If these instructions are not legible, you can also refer to the applicable aircraft TO for the servicing instructions. It is very important that you follow these instructions exactly.

Because of the various methods of servicing shock struts, we discuss only the most common method. It is called the hard strut method.

For efficient operation of shock struts, the proper fluid level and pneumatic pressure must be maintained. In order to check the fluid level, the shock strut must be deflated and be in the fully compressed position. Improper deflation of shock struts is highly dangerous; use approved precautions and procedures.

Remove all stands, jacks, and obstructions from under the aircraft. They could cause damage when the aircraft is lowered. Make sure all personnel are clear of the aircraft. This is to prevent the possibility of injury in case of a sudden collapse of the strut.

Remove the air servicing valve cap and release the air pressure in the strut by slowly turning the air servicing valve swivel nut counterclockwise approximately two turns. **CAUTION:** When loosening the swivel nut, insure that the body nut is held tight with a wrench. If it is loosened before the air pressure has been released, it could blow off and serious injury may result.

The shock strut should compress as the air pressure is released.

When the strut is fully compressed, the air servicing valve assembly may be removed by breaking the safety wire and turning the body nut counterclockwise from the strut. This provides a hole for checking the fluid level in the strut and for adding hydraulic fluid when needed. Fill the strut with hydraulic fluid to the level of the air valve opening. The strut has the proper amount of fluid when you cannot get another drop in it, without it overflowing. Reinstall the air servicing valve, using a new O-ring seal. Torque the air servicing valve body nut from 100 to 110 inch-pounds. Lockwire the air servicing valve assembly to the strut, using the holes in the body nut.

Attach a high-pressure air chuck and inflate the strut, using a regulated high-pressure source of nitrogen or dry compressed air. Under no circumstances should any type of bottle gas, other than nitrogen or compressed air, be used to inflate the shock struts. Nitrogen is preferred over compressed air. The amount a strut is inflated depends upon the specific aircraft strut being serviced. Figure 2-7 shows two ways of determining the amount a strut is inflated. In view A it shows a strut with the proper extension. It is measured from the center of the upper torque arm to the center of the lower torque arm. All you do is inflate the strut until you get this dimension. In view B you would have to use a strut inflation chart. The strut is measured as indicated at dimension "A." This measurement in inches is then located on the bottom of the inflation chart. For example, locate the measurement of 1.75 inches on the chart. Then from this point, trace an imaginary line vertically until it intersects the curved line. At this point of intersection, trace a second imaginary line horizontally to the left edge of the chart. The amount indicated at this point (550 psi) is the required pressure for that particular extension of the strut.

Whichever method you use to inflate the strut, the aircraft wings should be rocked while you service the strut with air (nitrogen). This helps eliminate any binding that might take place between the inner and outer cylinders. **NOTE:** Some aircraft must be placed on jacks with their struts completely extended in order to properly service them with air (nitrogen).

Once the strut is serviced to the specific amount, tighten the swivel nut on the air servicing valve to a recommended torque of 50 to 70 inch-pounds. Then remove the high-pressure air chuck and install the air servicing valve cap finger tight.

Proper servicing of shock struts cannot be over-emphasized. If servicing instructions are not closely followed, serious damage could result. Listed below are just some of the malfunctions that could happen if the struts are not serviced properly.

1. Improper oil level in the strut chamber will decrease the shock absorbing capabilities of the strut and could cause the strut to bottom out during landing, which would damage the strut and/or wing structure.

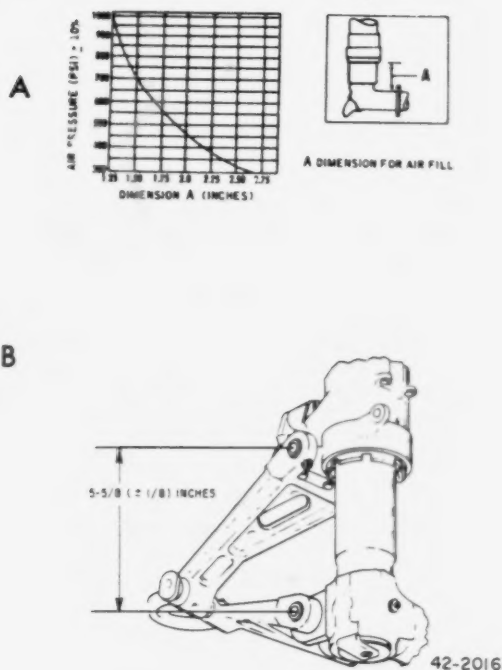


Figure 2-7. Shock strut servicing.

2. If the strut's chamber is underpressurized, the strut may not overcome normal O-ring friction during extension on takeoff. This condition could prevent the strut from fully extending, thus the scissors switch would not close the electrical circuit to retract the gear. It would also cause the strut to bottom during taxiing and landing operations.

3. If the strut's chamber is overpressurized, with fluid or air, it could cause the scissors switch to actuate. This could cause the gear to retract on the ground if the gear handle is accidentally moved from the DOWN position to the UP position. Also if the nose strut is overpressurized, it could prevent normal steering, due to the fact that the centering cams would be engaged.

Exercise (620):

1. Where would information for servicing the shock strut be found?
2. In order to check the fluid level of the strut, what must be done?
3. Cite some safety precautions that must be accomplished before the air is let out of the strut.

4. Referring to figure 2-7, view A, how much air must be placed in the strut if the strut shows 2.0 inches of extortion?
5. Why should the aircraft wings be rocked while servicing the strut with air or nitrogen?
6. How would you know the strut had the proper amount of hydraulic fluid in it during a servicing operation?
7. Why should all stands, jacks, and other obstructions be removed from under the aircraft prior to deflating the shock strut?
8. What would be the results if the shock strut was not filled with hydraulic fluid?

621. Specify the general procedures to follow when removing and installing a component in the nosewheel steering system.

Once again because of the varied aircraft and the many types of nosewheel steering systems, we give you information only of a general nature on the removal and installation of nosewheel steering components. For specified information pertaining to a specific aircraft, be sure and obtain the appropriate aircraft technical order.

Removing Nosewheel Steering Components. The removal of most nosewheel steering system components is rather simple. To give you an idea of what must be done, the following steps are presented.

1. Assemble all the tools and equipment needed to remove the component.
2. Depressurize the hydraulic system and remove electrical power. Since many nosewheel steering systems have pressure trapped in them for shimmy damper action, all the pressure may not be depleted.
3. Next, disconnect the hydraulic lines (fluid may squirt out because of the pressure trapped in the steering system for shimmy damper action). Cap or plug the lines to prevent contamination from entering.
4. Remove any electrical connection cannon plugs, quick disconnects, or switches.
5. If the components are mechanically controlled, such as the steering metering valves, the mechanical linkage must be disconnected.

6. Remove the mount bolts and the component.

Installation of Nosewheel Steering Components. The installation procedure is basically the reverse of removal. Once again, though, you should replace the O-ring seals with new ones.

Exercises (621):

1. During removal of a steering control valve, fluid squirted out of the unit even though the system had been depressurized. Explain how this is possible.
2. If a cap or plug was not installed after removal of a steering component, what could possibly happen besides creating a mess?
3. You are given a work order to remove the steer damper on an aircraft. What would be the first step you should take besides getting the technical order?

622. Specify the reason for, and how to, perform specific steps of the operational check of the nosewheel steering system.

Nose Gear Wheel System Checks. Nose gear steering checks are required when a malfunction of the system is discovered or on routine inspections. Following the instructions in the maintenance manual, you usually check the throw of the nosewheel steering for the following conditions:

- Full right travel.
- Full left travel.
- Neutral position.

Occasionally, adjustment of the mechanical control linkages of the nose gear steering system is required to permit a specified degree turn of the nosewheel to the left or right of neutral.

On some aircraft, it may be necessary for you to jack the nose of the aircraft in order to check for centering. The centering cams in the nose strut will position the gear to the straight ahead or neutral position. Some aircraft require that the nose gear be placed on grease plates. This consists of two metal plates with grease between them. This way the nose gear can be positioned without placing too much of a bind on it.

A simplified operational checkout requires that the nose gear upper torque link and torque collar be separated. Usually mounted at the nose gear is a plate that can be used to determine the distance the nose gear is moved, whether on grease plates or with the

torque links disconnected. We will discuss a typical nosewheel steering check.

Apply electrical and hydraulic power to the aircraft. Depress the control stick steering button. The nose gear should be in neutral 0°. Next move the rudder pedals full right, the nose gear torque collar should move to the maximum degree. Take your foot off the rudder pedal. The torque collar should return to NEUTRAL. Next move the nose gear full left. The nose gear steering collar should move to the maximum degree. Take your foot off the rudder pedal and the torque collar should return to NEUTRAL.

Reconnect the torque link and safety as required by applicable TO.

Exercises (622):

1. When the control stick steering button is depressed, what position should the nose gear be in?
2. Why do some checks require that a grease plate be used?
3. How can you determine how far the nose gear moves to the left or right?
4. Why is the aircraft jacked, in some cases, when checking the nosewheel steering?

623. Cite the reason for performing specific steps during removal, replacement, and bleeding of brake assemblies; and identify problems from situations pertaining to bleeding brakes.

Removing and Replacing Wheel Brake Assemblies.

When removing and replacing brakes, follow the specific aircraft technical order. However, the following are some of the most common procedures used:

1. Jack up the aircraft.
2. Release the hydraulic and/or pneumatic pressure as necessary.
3. Remove the main gear wheel.
4. Disconnect the hydraulic and/or pneumatic lines at the brake assembly. Be sure to cap or plug the lines.
5. Remove the brake-to-gear strut attachment bolts.
6. Lift off the brake assembly.

Reinstall brake assembly by reversing removal procedures. Be careful not to damage any lines or threads. After installation, bleed brake system and perform operational check to check for leaks.

Brake System Bleeding. Air in a brake system may result from a lower reservoir fluid level, from external leaks, or from removing or replacing a unit. If there is air in a system, the brake pedal feels spongy when depressed instead of solid as it would be if the system has been properly serviced and bled. Two methods are used to bleed air from aircraft hydraulic brake systems: the gravity method and the pressure method.

Gravity method. The gravity method consists of pumping fluid through the system, using the master cylinder as a pump, as shown in figure 2-8. When using this method, connect a bleed hose to the bleeder port on the top of the brake unit. Place the free end of the hose in a clean receptacle containing hydraulic fluid. Depress the brake pedal slowly several times to pump the hydraulic fluid through the system into the receptacle. Close the bleeder port on each return stroke of the brake pedal to prevent fluid and air from being drawn back into the system from the receptacle. Continue this operation until no air bubbles appear and the spongy pedal action is eliminated. During this operation, be sure that plenty of hydraulic fluid is kept in the brake reservoir. If the reservoir is allowed to run dry, air is drawn into the system by the operation of the master cylinder.

Pressure method. The pressure method of brake bleeding consists of forcing fluid through the system with a brake bleeder, as shown in figure 2-9. When using this method, first connect a bleed tank to the bleeder port on the brake unit. Air pressure in the

tank removes the air by forcing the fluid through the system to the reservoir. Drain some fluid from the brake system reservoir to prevent it from overflowing. The amount of air pressure in the bleeder tank and the amount of fluid forced through the system varies with the aircraft concerned; therefore, you should always consult the brake servicing portion of the applicable -2 technical order before bleeding the brake system.

On aircraft with power brakes, the brake system is usually bled by the gravity method; however, there must be pressure in the hydraulic system, so that the brake system can receive fluid when the brake metering valve is operated.

Exercises (623):

1. The brakes on your aircraft are reported to be spongy after the installation of a new brake assembly. What is the most probable cause of this condition?
2. A subordinate has gravity bled the brake system to correct spongy brakes. Extreme sponginess develops after he has completed the procedure. What step did he omit which caused this condition?

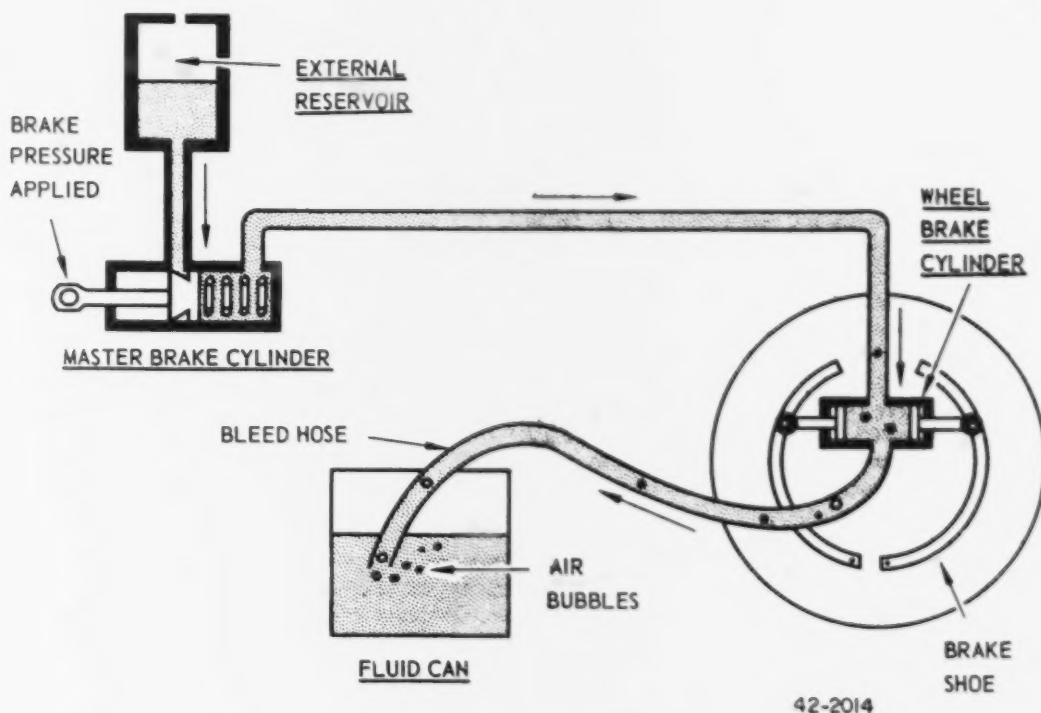


Figure 2-8. Bleeding brakes (gravity method).

3. While you are bleeding the brake system using the pressure method, the hydraulic reservoir overflows. What is the probable cause of this condition?
4. During the removal of the brake assembly, why should the lines be capped or plugged when removed?
5. When bleeding the brakes using the gravity method, the bleeder port is closed on each return stroke of the brake pedal. Why is this necessary?
6. When using the pressure method of bleeding brakes where in the brake system is the bleed tank connected?
7. When using the gravity method of bleeding the brakes, how often must the brake bleeder port be opened and closed?

624. Arrange in proper sequence the steps for performing an operational check of the wheel brake system.

Wheel Brake System Operational Check. The operational check of the brake system is conducted to assure satisfactory operation of the brake system after replacement of a component in the system, to check for leaks in the system, to isolate trouble if a malfunction is suspected in the system, and/or to meet routine inspection requirements.

At least two men should perform the operational check of the brake system. One operates the system and performs the necessary checks in the cockpit. The other performs the necessary functions and checks at the landing gear wheels, service valves, and the external hydraulic test stand (if used).

The operational check is very similar on all aircraft except for specific items. The checkout requires the use of an electrical power source, hydraulic power source, and two hydraulic pressure gages. The two gages are installed in the bleed valves after cleaning the valves with solvent. Insure that the landing gear handle is down and antiskid switch is off. Connect electrical and hydraulic power to the aircraft. One man in the cockpit applies the brakes while the ground man checks for specified pressure (as an example 2700–3000 psi on the gages) and applied brake discs. The brakes are then released; the pressure in the gages

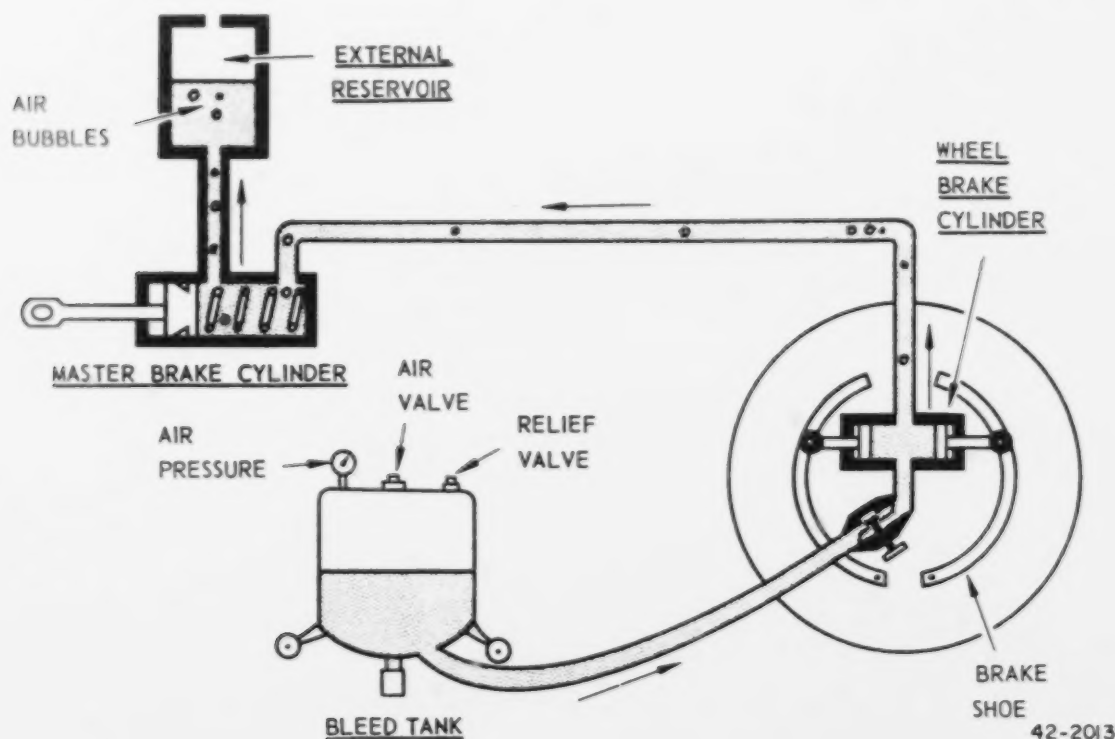


Figure 2-9. Bleeding brakes (pressure method).

should decrease (as an example, to 50 psi or less) and the brake discs should be loose. Place the antiskid switch to ON and observe if the antiskid light goes out. Apply brake pressure and observe the pressure gages. Place antiskid switch OFF. The light should go out. Next, check the brake pedal binding with a spring scale for resistance when the pedal is depressed slightly. Then apply hard pressure to both brake pedals, observing pedal position and negative pedal fade. This completes the checkout procedures. The pressure gages and electrical and hydraulic power can be removed from the aircraft. In the event of malfunction during any brake check, refer to the applicable -2 TO.

Exercise (624):

1. Arrange in the correct sequence the steps for performing an operational check of the wheel brake system by placing a letter by each of the following steps:

- Step 1. — a. Connect electrical and hydraulic power.
- Step 2. — b. Place antiskid switch ON—Light is out.
- Step 3. — c. Insure that landing gear handle is down and antiskid switch is OFF.
- Step 4. — d. Apply brakes and check pressure gages.
- Step 5. — e. Install gages in bleed valves.
- Step 6. — f. Release brakes and check pressure gages.
- Step 7. — g. Apply brakes and observe gages.
- Step 8. — h. Check for brake pedal binding.
- Step 9. — i. Place antiskid switch to OFF—Light is out.
- Step 10. — j. Apply hard pressure to both pedals and check for negative pedal fade.
- Step 11. — k. Disconnect power and gages from the aircraft.

625. Specify the operating principles that pertain to the bench check and repair procedures of hydraulic components.

Bench Check of Components. When a unit is taken from an aircraft, it usually ends up in the shop for a bench check. It can either go directly to the shop or it can go through the supply channels of the reparable processing center (RPC). As with any other job, there are set procedures for bench checking. In this section we discuss these procedures in detail, starting with the first steps and moving on until the unit is ready to be repaired.

You should know that the first thing to be done, in any job, is to locate the applicable TO. In Volume I we have discussed the procedures for finding the proper TOs. Not needing to repeat this, we can go directly on to the following steps.

Inspect for obvious damage. This action involves a general external inspection of the unit. You should check for any visible damage to the unit that could cause the malfunction or discrepancy. Such things as cracks in the body or stripped threads in the ports are considered obvious damage.

Just because you find obvious damage is no reason to stop without completing the bench check. After all, these defects could have been caused during removal of the unit. Therefore, you should always complete the job to see if there is anything more than obvious damage. It would be rather embarrassing if you should wait 2 or 3 days for a valve body and then found that some other parts of the unit were bad, also.

Disassembly. Many TOs tell you to disassemble a unit by following the index numbers of the parts breakdown figure. Those that do not do this will list the complete procedures for disassembling the unit. Either way, lay out all parts in an orderly manner, so that they can be put back together in the correct sequence.

More clues to the unit malfunction can be found during disassembly. You might, for example, find a poppet stuck open. Or you might discover that a slide has been scratched, causing excessive leakage at one port.

Cleaning. When the unit has been disassembled, clean all of its parts. How they are cleaned depends upon the construction of the unit. For instance, you should not use PD-680 solvent on a unit not compatible with petroleum base solvents. However, PD-680 is suitable for any unit that comes into contact with hydraulic fluid.

The parts of a unit are cleaned for several reasons. One is so that there will be no foreign matter left to contaminate the system when the unit is reassembled. Such foreign matter could clog an orifice or cause a poppet to stick. Also, clean parts assure more accurate inspection than dirty ones.

Inspection. After a unit has been disassembled and its parts cleaned, you should inspect the parts to insure their serviceability. Check for nicks and scratches that could cause a leak. Measure the tension of springs and check your findings against the limits listed in the applicable TO. Insure that all slides properly seat in their sleeves and that they move freely.

During this inspection, you should list all parts that are bad or are doubtful. Use this list when you order parts to repair the unit.

Ordering Parts. Now that you have a list of parts needed to repair a unit, you will have to order them. Just as the overhaul time you spend is charged to the unit, so too are the parts you order for it charged to it.

Units brought to the shop for repair normally have a supply document number. This number is used for identification and control of repairable items. When you order parts for a unit, you identify the unit that the parts are to be charged to. Reference the unit by using its document number. Furthermore, each *recoverable* part you order for a unit has its own document number.

Shortly after you order these parts, supply can tell you whether or not you will receive them at once. Back order those not on hand in supply. Normally, not until all parts are received do you begin the repair of the item. This brings us to the repairing of an item.

Repair of Components. Unless circumstances prevent it, bench check and repair actions are normally taken at the same time. After you have bench checked the unit, you would logically begin to repair it. A circumstance that would prevent this is when all parts needed for repair are not available. In such a case you should put the unit with all its parts in an AWP (awaiting parts) storage bin.

Assuming all parts are available, we list the procedure for repair of a unit. Because we are repairing it immediately after completing the bench check, we can assume you already have the correct TO on hand.

Reassembly. The first step in repairing a unit is reassembling its parts. There are several precautions you must observe when you are doing this. To begin with, all O-ring seals and gaskets must be replaced. The sequence for reassembling a unit is usually the reverse of its disassembly. That is, the parts you took off last will probably go on first.

When you are reassembling a unit, remember to put parts back in the same position from which they were removed. As an example of this, think of yourself as working on a solenoid valve with two apparently identical parts. You must replace these and other items in their original position, because they may be mated to their retainers. You cannot change just the slide of a slide and sleeve assembly either, because they come in matched sets.

When you have reassembled the unit, you are ready to test it. Before you start your testing procedure, it is wise for you to go back over the steps in the applicable TO, just to make sure that nothing has been missed.

Test procedures. A unit that has been overhauled must be operationally checked. After all, just because you have changed a solenoid in a valve, doesn't mean that the valve will now operate properly. But you must make sure that it operates flawlessly before you send it back to supply as serviceable. Remember, you might be the one who has to put it on an aircraft, and then find out that it doesn't work correctly.

Exercises (625):

1. What does "Inspect for obvious damage" indicate?
2. Explain why parts are cleaned during bench check.
3. If an item has matched parts, what should be done with them?
4. Why must a component that has been repaired be tested?
5. Why is it important to check each part of a component for serviceability?
6. When you order a part for a unit, what document number do you reference?
7. What circumstances would prevent you from repairing a unit when it is bench checked?
8. If all the parts needed to repair a unit were not available, what would you do with the unit?

Aircraft Flight Control Systems

AFTER A touch-and-go landing, the pilot noticed a rolling tendency and heavy left-wing condition. The situation deteriorated until full right stick and rudder would not maintain wing-level flight. The pilot radio transmitted his difficulties and ejected while the aircraft was rolling out of control. He landed uninjured, but the aircraft was destroyed.

An investigation revealed that the accident was caused by a missing cotter pin. The cotter pin for the control bolt connecting the right-wing aileron servo valve to the push rod had either not been installed or had been installed incorrectly. This allowed the nut to come off and the bolt to work out. The uncontrollable servo valve then caused the actuator to drive the right aileron to the FULL DOWN position and keep it there. This resulted in a complete loss of aileron control.

No systems in the aircraft require more reliability of operation than do the flight control systems. The flight control systems must function properly. If they do not, the aircraft can become an object of destruction and the pilot can be injured or killed. For this reason, flight control systems have always been of great concern of the manufacturer. With this in mind, let's review the flight control systems.

3-1. Flight Control System Description

"You can have power steering on this model for just a little more," the salesman said. You think it over. You think how nice it would be to be able to park in those tight parking places without all that twisting and tugging at the steering wheel. You think how nice it would be not to have that feeling of exhaustion after a long drive. You wouldn't be without power steering, now. This also applies to modern aircraft, as we shall see.

Terrific pressures are exerted on the control surfaces (ailerons, stabilators, rudder, etc.) of today's supersonic aircraft. Powered control surfaces allow the pilot to overcome these pressures with ease. Many such systems used on modern jet fighter aircraft are equipped with automatic flight control systems that accomplish complex flight maneuvers. Sloppy inspection and maintenance of the basic flight control systems not only result in multiplication of error under automatic control but have also at times resulted in

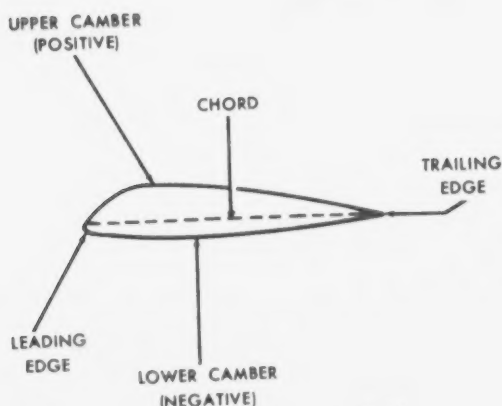
serious accidents. In this chapter, we review fundamentals of basic flight control systems and applications used in more sophisticated control systems with emphasis on inspection and maintenance.

626. Define camber in relation to an airfoil, and specify how the aerodynamic forces act upon the lift necessary for flight.

Principles of Flight. To understand his job, the pneumatic specialist must have some knowledge of the principles of flight. No doubt, man got the idea of flight from watching the birds soar gracefully overhead. His early attempts at flight were, for the most part, fantastic, if not fatal. He even tried to imitate the birds by attaching wings to his arms and shoulders. It just did not work, because in his early attempts to fly, man didn't know enough about aerodynamics. First, let us review the characteristics of an airfoil and the forces acting upon it in flight.

Airfoils. Figure 3-1 shows a typical airfoil. Note that the two edges of the airfoil differ in appearance. The edge that faces into the wind in flight is called the leading edge. The other edge is called the trailing edge. A reference line often used in discussing an airfoil is the chord line. This is a straight line drawn through the airfoil. The line connects the farthestmost points of the leading and trailing edge. It is about parallel to the longitudinal axis of the aircraft. A most important factor of an airfoil's lifting ability is camber. Camber is the curve of the surface of an airfoil from the leading edge to the trailing edge. Notice, in figure 3-1, the upper camber is longer than the lower camber. This difference has an effect on the amount of lift (and drag) the airfoil produces.

Aerodynamic forces. Now let's review the four aerodynamic forces acting upon an aircraft: lift, weight, thrust, and drag. The *lift* of the airfoil acts upward at a right angle to the direction of the relative wind. Relative wind is the airstream striking the moving airfoil. The *weight* (gravity) acts vertically downward from the center of the gravity of the aircraft. *Thrust* is the force that moves the aircraft forward during flight. *Drag* is the resistance of the atmosphere to the aircraft's forward motion. When



42-79

Figure 3-1. Airfoil.

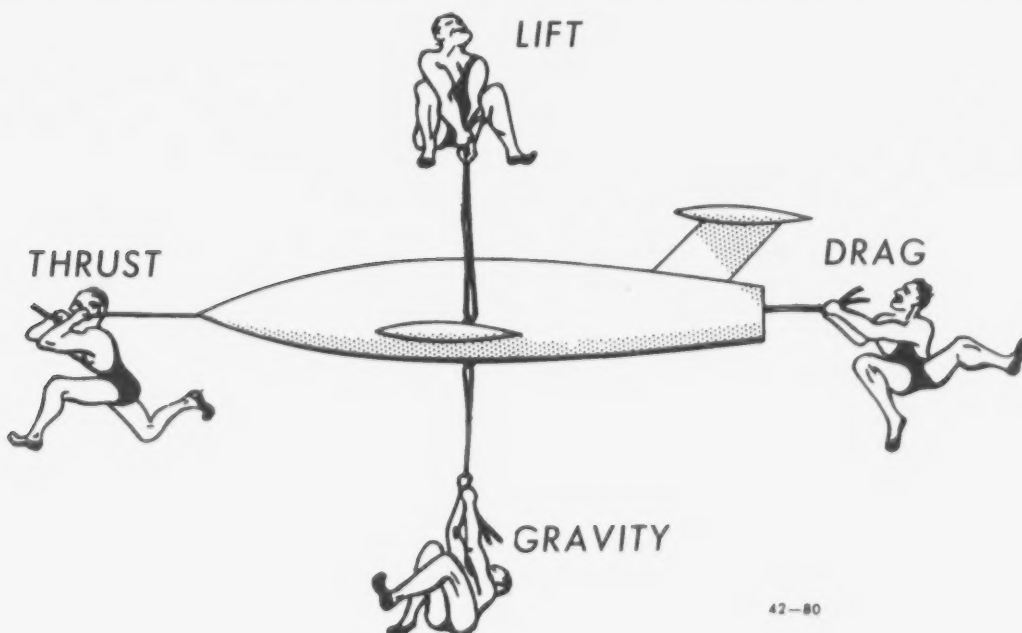
the aircraft is in straight and level unaccelerated flight, the lift equals the gravity and the thrust equals the drag. Figure 3-2 shows how the opposing forces balance each other. The lift forces the airfoil up; at the same time, the resistance (drag) pulls the wing backward.

The other two forces, thrust and weight, affect the airfoil movement. The thrust causes the airfoil to move forward. The weight (gravitational pull) causes the airfoil to fall toward the earth. As you will note, the forces act in different directions and balance each other. If the lift is as great as the weight, the aircraft neither rises nor falls (climbs nor dives); if the thrust

is as great as the drag, the aircraft does not move either faster or slower; the speed is constant. To go faster, we merely make the thrust larger than the drag, and the aircraft accelerates. Soon the thrust and drag again equalize. Now the aircraft no longer accelerates but moves ahead at a constant speed, but faster.

The laws of lift and the venturi. The last two principles to consider in our review of flight are the laws of lift and of the venturi. The first law can best be illustrated by holding your hand out of the window of a moving automobile. As you tilt your hand, the force of the air against your hand has a tendency to move it. The airfoil, in this case, is your hand, and it deflects the wind. This action creates a pressure on the lower surface of your hand, forcing it upward and backward (lift and drag). The second law relates to the venturi principles. You learned about venturis in Volume 2. When an airfoil moves through the air, both the airfoil shape and angle of attack cause the air to be deflected. The deflection slows the air below the airfoil, causing a high-pressure area under the surface. The air moving across the upper surface of the airfoil travels a longer distance. This causes an increase in air velocity. This increase in velocity produces low pressure next to the upper surface of the airfoil. In this manner, a pressure differential acting on the top and bottom of the wing creates the lift. As the speed of the airflow increases, the pressure differential (and lift) also increases.

We have already pointed out that drag is the resistance of atmosphere to the airfoil's forward motion. The drag will always act parallel to the relative wind. The relative wind is the direction of the airflow



42-80

Figure 3-2. Aerodynamic forces.

with respect to the airfoil. If an airfoil is moving forward horizontally, the relative wind moves rearward and upward. The angle of attack of an airfoil directly controls the distribution of pressure above and below it. The angle of attack can be defined as: the angle between the chord of an airfoil and the direction of the relative wind. Whenever one of the conditions is changed, it will affect another. For example, if speed is increased, angle of attack will change. This speed increase causes a pressure change above and below the airfoil. The pressure change causes the aircraft to climb because of a greater lift from the airfoil. To maintain *constant* lift, the airfoil's velocity must be decreased as its angle of attack is increased. You can see from this, then, how the necessary lift for flight is produced.

Exercises (626):

1. Define camber in relation to an airfoil.
2. What aerodynamic force moves the aircraft forward during flight?
3. What force will pull the wing of an aircraft down?
4. What aerodynamic force will increase as the speed of the airflow across the airfoil is increased?
5. What force will always act parallel to the relative wind across the airfoil?
6. What controls the distribution of pressure above and below the airfoil?
7. The airfoil cord line is parallel to what axis of the aircraft?
8. When will lift be equal to gravity and thrust be equal to drag?
9. For the aircraft to move at a constant speed, what two forces must be equal?

10. How is the lift of a wing created?

627. Specify the location and use made of the flight control surfaces.

Flight Characteristics. There are three axes about which an aircraft may turn, as shown in figure 3-3. These axes are imaginary lines passing through the aircraft's center of gravity. You might think of these axes as imaginary axes around which the aircraft turns like a wheel. Each of the axes is perpendicular to the other two. The axis that extends from the nose of the fuselage to the tail is the *longitudinal* axis. The axis that extends crosswise, from wingtip to wingtip, is the *lateral* axis. The axis that passes vertically through the center of gravity is called the *vertical* axis. The motion about the longitudinal axis is called *roll*. The

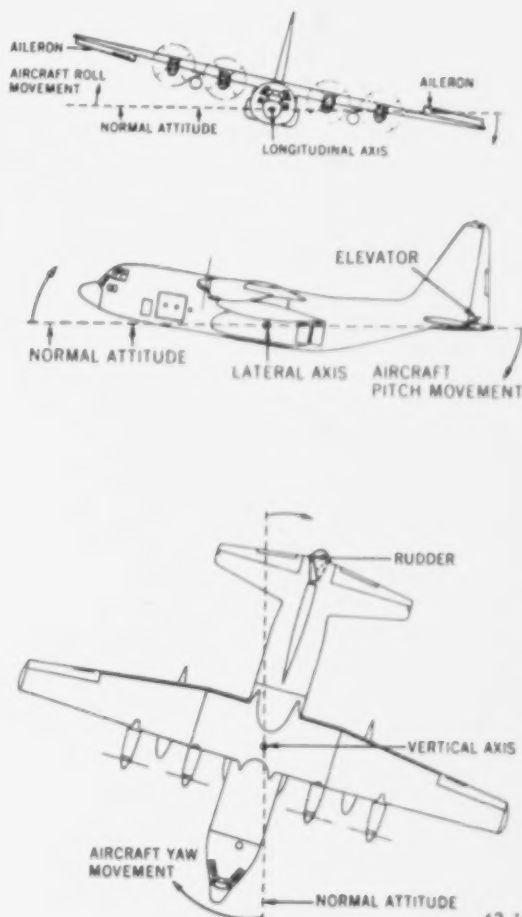


Figure 3-3. Flight axis.

42-1999

motion about the lateral axis is called *yaw*. When the attitude of an aircraft is changed in flight, it will move around one or more of its axes.

Now you have become familiar with a few of the characteristics of flight and the different forces that act on the aircraft. Next look at the various surfaces used in controlling movements of the aircraft in flight.

Flight Control Surfaces. It is very simple to change the direction of a bus, car, or truck by merely turning the steering wheel. Changing the direction of an aircraft as it flies involves the movement of flight control surfaces. These flight control surfaces are located in various areas of the aircraft.

Elevators. The elevators, as shown in figure 3-3 center, are used to make the aircraft dive or climb. This is done by controlling the angle of the surface with respect to the air flowing over it. The elevators are hinged to the trailing edge of the horizontal stabilizer. They are connected so that they always operate together. Forward and aft operation of the control stick moves the elevators up and down. This movement controls the aircraft about the lateral axis. Downward force on the tail causes the nose to rise and increases the wing angle of the attack. This increases the lift and causes the aircraft to climb if the speed is maintained. If the pilot moves the control forward, the elevators move downward. The lift will decrease and the aircraft will lose altitude.

Rudder. The rudder, as shown in the lower part of figure 3-3, is hinged in a vertical position at the trailing edge of the vertical stabilizer. Controlled by the movement of the rudder pedals, it guides the movement of the aircraft about the vertical axis. When the pilot applies pressure on the right pedal, the rudder moves to the right. The tail of the aircraft is thus forced to the left, rotating the aircraft about its vertical axis. When the tail is moved to the left, the nose of the aircraft is moved to the right. Pressure applied to the left pedal reverses this action.

If the pilot makes a turn with a rudder alone, he normally finds that the aircraft will sideslip. This is similar to an automobile trying to take an unbanked curve too fast. The skidding is caused by centrifugal force. The pilot prevents this skidding (or sideslipping) by banking. Banking is the coordination of rudder and ailerons in a turn.

Ailerons. The ailerons, as shown on the top of figure 3-3, are located in the trailing edge and toward the tips of the wings. Their movement is controlled by the pilot's control stick or wheel. From the pilot's control, the linkage is arranged so that if one aileron goes up the other goes down. For a right turn, the right aileron is raised, which forces that wing down. The left aileron has moved down which results in more lift on the left wing; the wing then rises.

Movable horizontal stabilizer. During flight at transonic (at speed of sound) speeds, the airflow over the horizontal stabilizer creates shock waves. These shock waves form air fences ahead of the elevators that result in the loss of elevator control.

To correct this, present-day aircraft are equipped with a movable horizontal stabilizer. It gives the pilot faster and firmer control over his aircraft. The control stick is connected to the horizontal stabilizer through mechanical and hydraulic units. These aircraft have no elevators, and the pilot flies the aircraft with the horizontal stabilizer. When the stabilizer control stick is moved aft, the stabilizer leading edge moves down and the nose of the aircraft moves up. Figure 3-5 shows the location of the flight control surfaces used on one of today's modern-type aircraft.

Tab. Tabs are located on the trailing edge of controls such as the elevator, rudder, and ailerons. Their reaction in the airstream, however, is the same in all three cases. For example, we wish to trim an aircraft in pitch. In order to raise the nose of the aircraft, the tab must be moved down. The reason for this is clearly shown in figure 3-4. The primary control surface, in this case the elevator, is hinged to the horizontal stabilizer. The tab, in turn, is hinged to the elevator. A movement of the tab causes a powerful movement to be exerted on the primary control surface. The result of this force is a small movement of the elevator in the opposite direction. Therefore, if the tab is moved down, the elevator moves up. Since the aircraft responds only to the action of the primary control, the tail drops. This raises the nose of the aircraft.

Spoilers. Spoilers are of several different types. In effect, they momentarily destroy or interrupt a part of the lift pattern on a wing. Figure 3-6 shows the action of one type of spoiler.

This spoiler is recessed into the upper chamber of the wing (see fig. 3-6). In the top part of figure 3-6, the spoiler is not used. The flow of air over the wing is smooth and uninterrupted, and the full lifting power of the wing is realized. However, assume that a gust of air has caused the *left* wing to go down. The automatic flight control system instantly sends out a signal for the spoiler on the *right* wing to rise. By this action, the lift of the *right* wing is "spoiled" by the turbulence created by the spoiler. The right wing will begin to drop. (See bottom part of fig. 3-6.) Since the spoiler on the *left* wing is still recessed, the lift on that wing is now greater.

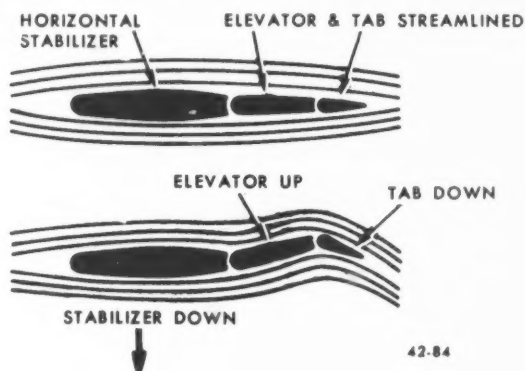


Figure 3-4. Trim tabs.

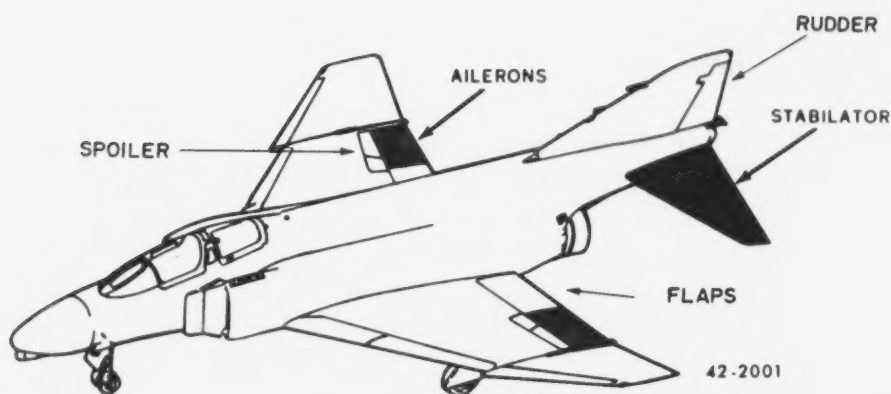


Figure 3-5. Flight control surfaces.

This results in the left moving itself up to normal level flight. While this is going on, the right-wing spoiler moves back to the recessed position.

An extended spoiler causes drag on one wing, which may cause the aircraft to yaw. Therefore, when the spoiler extends, the rudder may be actuated at the same time to prevent yaw.

Speed brakes. These are used to increase drag to slow the aircraft and reduce landing distance. Several types of speed brakes are in use. The principle of operation is the same for combination or independent systems. Some aircraft use a combination spoiler speed brake system. On others, the systems are independent of each other. When the spoilers are used as speed brakes, both sides rise together. Some of these combination systems also allow the speed brake to be raised in various degrees. Fighter aircraft often use another type. Usually, this is just a large spoiler extended from the lower fuselage area.

Wing flaps. The wing flap is a dual-purpose control, used to increase lift and also used to increase drag. Wing flaps are located under the trailing edge of the wings. Normally, about 25 percent flaps down is used for take-off and full down flaps are used for landing. The increase of lift and drag means a slower landing speed and a steeper gliding angle.

Besides the plain flap, there is the split flap, figure 3-7, center, consisting of a hinged section of only the lower chamber. The upper chamber remains stationary as part of the wing structure while the lower section drops. The leading edge flap is hinged to the front of the wing structure.

The most efficient type of flap is the Fowler flap, figure 3-7, bottom view. In this type, the flap moves down and slides aft on a track at the same time. This type is more effective, because it increases wing camber.

Exercises (627):

1. Forward and aft movement of the control stick controls the movement of the aircraft about which axis?

2. What control surface is hinged to the trailing edge of the vertical stabilizer?
3. Which primary flight controls are located in the trailing edge and near the tips of the wings?
4. When the control stick is moved to the right, which direction do the ailerons move?
5. What flight control surface controls the aircraft about its vertical axis?
6. Where are tabs located?

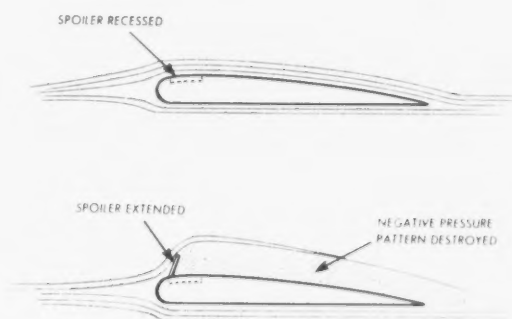


Figure 3-6. Spoilers.

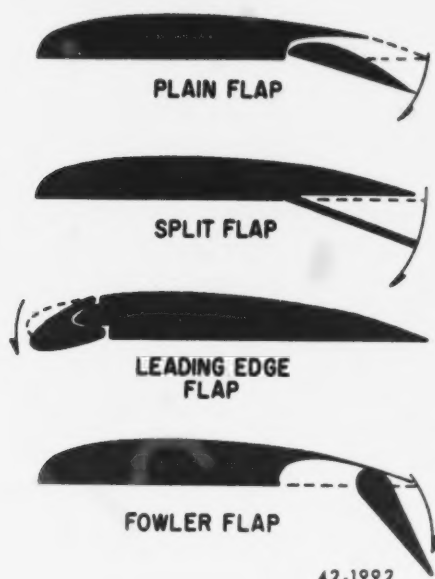


Figure 3-7. Types of flaps.

7. What control surface will momentarily interrupt or destroy a part of the lift pattern on a wing?
8. What control surface when extended will cause the aircraft to yaw because of the drag it may cause on one wing?
9. What is the purpose of speed brakes?

10. What are the two purposes of the wing flaps?

11. Where are the wing flaps located?

12. What flight controls control the aircraft about the lateral axis?

13. What flight control can be used to trim an aircraft in pitch?

14. If an aircraft has no elevators, what gives the pilot control of the aircraft about the lateral axis?

628. Specify the use made or purpose of various systems that aid the pilot in flying the aircraft.

Artificial Feel System. In very early flight control systems, the pilot moved the control stick and the mechanical linkage (push-pull rods) operated the control surfaces. With this system, the pilot has a definite feel of the amount of air pressure that he is forced to overcome with control stick operation. See figure 3-8. This, however, turned out to be one disadvantage of the direct manual system because the airload forces on the control surfaces would vary with the speed of the aircraft. With the advent of newer and faster models of aircraft, such high airloads are encountered that the

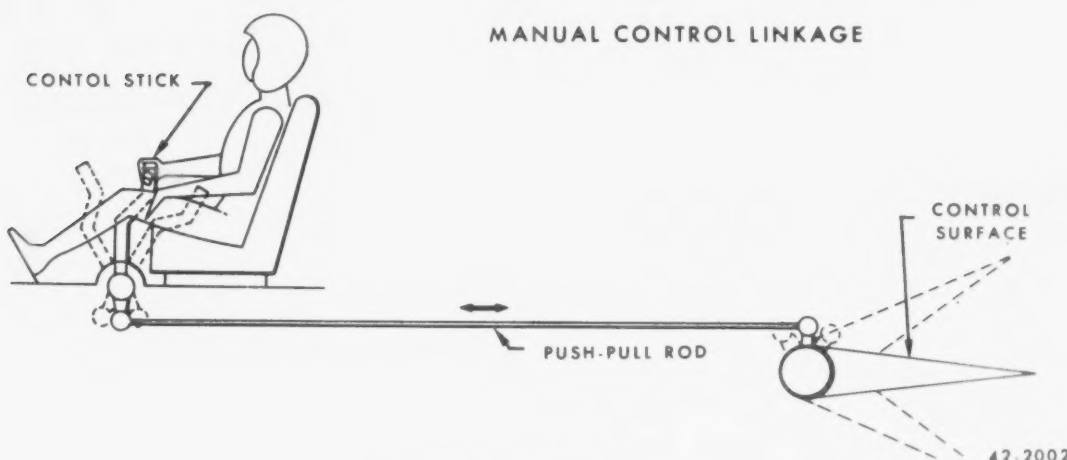


Figure 3-8. Mechanical flight controls.

task of flying the aircraft exceeds the physical capabilities of the pilot. To compensate for the increased airloads, a powered flight control system using hydraulic pressure was developed. With this type of system, the pilot does not move the control surface directly but only positions a control valve. The control valve directs hydraulic fluid to either side of an actuating cylinder. It was found that even though it made it easier to move the control surfaces, the pilot had no feel of the control surface airload. This usually made the pilot demand too much control surface movement when he moved the control stick. To compensate for this, a large spring was installed to the mechanical linkage to simulate an artificial aerodynamic load. This system is called the artificial feel system.

Electrical Trim System. The trim system is used to make minor movements of the flight controls rather than using the control stick. The trim switch for both the elevators and ailerons is normally located on the control stick, figure 3-9. The trim switch is used to energize electrical motor actuators that position the hydraulic control valve. Here is how it works. If an aircraft is perfectly balanced, it should be able to fly straight and even when the control surfaces are streamlined. If the aircraft becomes unbalanced, a control surface must be moved in order for the aircraft to fly straight and level. When an aircraft is not balanced it is said to be "out of trim." When the trim switch is positioned, it moves the control surface just enough to compensate for the out-of-trim condition. This causes the aircraft to become balanced again.

Automatic Flight Controls. One system of vital importance on a modern aircraft is the automatic flight control system (AFCS). The AFCS is broken down into two major parts; stability augmentation (stab aug) and autopilot (A/P) systems.

Stability augmentation. The stability augmentation system serves two functions. First, it automatically coordinates the turns and smoothes out the bumps as the aircraft passes through turbulent air. Second, it improves the handling characteristics when the pilot is flying the aircraft manually. On commercial aircraft, the stab aug system is used to give the passengers as smooth a ride as possible. On an Air Force fighter or bomber, the stab aug is used to make the aircraft a stable platform from which weapons can be launched.

Autopilot. The autopilot system on military aircraft is used for pilot relief. That is, on long flights it can be used to fly the aircraft automatically along a predetermined course selected by the pilot. The electronic equipment in the autopilot system controls the aircraft in various modes. A brief explanation of each mode is listed below.

- **Attitude hold.** Pitch or roll is the basic autopilot mode of each axis. The attitude hold will hold the aircraft at the reference attitude until another mode is selected.

- **Altitude hold.** In this mode, the autopilot automatically maintains the aircraft at a constant barometric altitude.

- **Mach hold.** This mode automatically maintains the mach speed of the aircraft. This is done by varying the pitch attitude of the aircraft.

Exercises (628):

1. What is used in the flight control system to prevent overcompensating when the control stick is moved?
2. Can the force of the air against the control surface be felt by the pilot when a hydraulic power system is used?
3. To compensate for small unbalanced conditions of the aircraft, what can be used?
4. What are the two main systems contained in the AFCS?
5. What is the purpose of the stability augmentation system on an Air Force fighter or bomber?
6. What is the purpose of the autopilot system in most aircraft?

629. Identify the control linkage units and their related functions.



Figure 3-9. Trim switch.

Types of Linkage Systems. Figure 3-10 illustrates the classification of control linkages according to construction: the three types of cable systems, push-pull rods, and various combinations of the two.

Cable system. On jet aircraft, the cable system is generally used to operate the rudder. The cables are flexible. This permits routing around obstacles by the use of pulleys, quadrants, and bellcranks. They can be installed over long distances without a great degree of sagging. However, they must be worked in pairs—one to move the control surface in one direction and the other to move it in the opposite direction. There is no lost motion, since the cables are stretched tight and very little play is present in the system controls. As a consequence, cable-operated flight controls respond quickly and accurately to cockpit controls movement.

Push-pull rod system. In a push-pull rod system, the surface control is connected to the cockpit by means of rods. The movement of the cockpit control is transferred to the control surface by either a push or pull force on the rods.

In addition to gaining greater rigidity in the control linkages, push-pull rods are less affected by temperature change than cables. Also, only one push-pull rod is necessary to perform the same function requiring two cables. In some cases, however, push-pull rods are difficult to rotate through or around obstacles to reach the control surface to be actuated.

Combination system. The combination of both cables and push-pull rods is used where convenience demands. Since this combination uses both cables and push-pull rods, it makes use of most of the control linkage units used in both the other systems.

Control Linkage Units. Control linkage units are those items needed to route and connect the cables from the control device in the cockpit to the surface or unit.

Cables. An aircraft control cable is simply a wire rope made of flexible steel, usually corrosion-resistant, and it varies from 1/16 to 3/8 inch in diameter. Cables measuring 1/8 inch or larger in diameter are normally used in primary flight control systems. Smaller cables (less than 1/8 inch in diameter) are generally used in trim and engine control systems.

Cables are prefabricated to fit either from turnbuckle to turnbuckle or from turnbuckle to unit. The strength of a cable is usually 50 percent in excess of the design loads to be sustained. Because of this and because of the number of individual wires, failure of the cable is never abrupt but is progressive over periods of extended use. Some broken wires may appear in the cable soon after it is put into service, usually happening because some wires are under more tension than others. Usually, after the first few wires break, it will be quite an interval of time before any more broken wires show up. It has been proven that the loss in cable strength due to broken wires depends on their concentration within an area rather than the total number of breaks in the cable.

Cable hardware and fittings. To make proper use of the cables connecting the controls, certain types of fittings, called terminals, are attached to the cable ends.

Four methods are used to attach the terminals to the ends of the cables—swaged, sweat-soldered, wrap-soldered, and woven splice. The swaged terminal is standard for most jet aircraft cables carrying light loads. The wrap-soldered splice and the woven splice are used only as emergency replacements for the other two.

Turnbuckle. This device is used to join cable ends and to adjust cable tension. The turnbuckle barrel is threaded with internal left-hand and right-hand threads at opposite ends. The cable terminals are also threaded with left-hand and right-hand threads. Turning the barrel will vary the tension on the cable. In this way the cables are either loosened or tightened, depending upon which way the barrel is turned.

Turnbuckles are purposely located and grouped in the aircraft to make maintenance and inspection easier. Generally, in the fuselage the right-hand threaded end of the turnbuckle barrel faces toward the front of the aircraft, and in the wings it points toward the wingtips. Some barrels are marked on the left-hand threaded end with either a circular groove or a knurl.

Cable quick-disconnect unit. Sometimes this unit is called a cable tension release fitting. It is installed in the cable system on many jet fighters to permit a quick and easy disconnect and reconnect to the cable system without the necessity of resetting the cable tension. On most fighter aircraft, many quick-disconnect units are found at the fuselage break point. Since engine change may require that the aft fuselage be separated at this point, it may often be necessary to disconnect rudder trim and other flight control cables. When the disconnect unit is loosened, the tension on the cable is

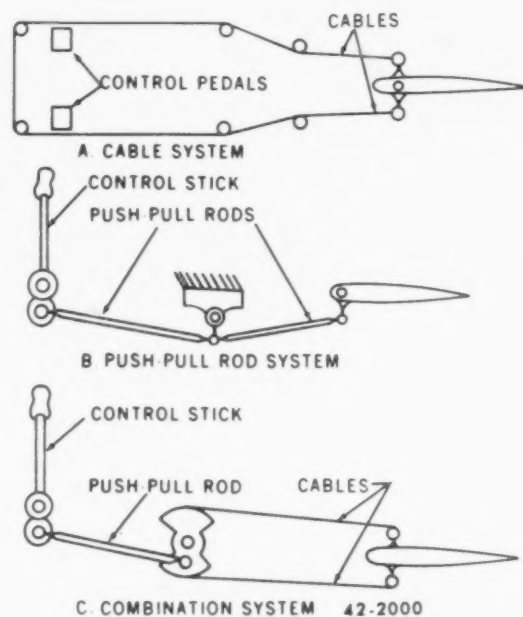


Figure 3-10. Types of linkage.

released, allowing the cable to be disconnected. Closing the cable quick-disconnect unit restores the cable to its original length and tension.

Pulleys. These components, used on flight control systems, are made of phenolic or other nonmagnetic materials. As control cables scarcely ever run straight from one point to another, pulleys are used to change direction, to change the angle of pull, or to clear obstacles. Most pulley are made with sealed bearings and require no further lubrication.

Fairlead. This serves to keep the cable controls from coming in contact with structural parts of the aircraft. It reduces vibration and sag. It also permits cables to pass through bulkheads without coming into direct contact with the bulkhead, thus preventing chafing and wear to the cable.

Pressure seals. These are used to prevent loss of cabin pressure when cables are routed through pressurized areas on the aircraft. These units are usually made of soft rubber material and clamp around the cable to make a pliable, airtight seal.

Quadrants and bellcranks. These units are used to transmit motion about an axis and to change the direction of force of a cable or push-pull rod. The use of one or the other is usually determined by the location of the control, the control itself, and the amount of motion involved.

Stops. These are mechanical devices used to limit the range of movement of a control surface or unit. The stops may be either fixed or adjustable.

Torque tubes. Rods or shafts (torque tubes) are simple machines used to transmit torque or motion about an axis. The drive shaft of an automobile is a good example of a torque tube. Torque tubes are used in flight control systems to transmit force (torque) from one unit to another.

Push-pull rods. These are rigid rods that transmit both push and pull motion. The rods may be adjusted at either or both ends; loosening the locknut permits adjustment by threading the end fitting in or out as needed. A small drilled hole in the terminal is used to check for engagement of the rod. When a piece of safety wire can be inserted in the hole, the terminal is not engaged enough.

Exercises (629):

Identify the control linkage units in column B by matching them to their function listed in column A.

Column A Function	Column B Unit
— 1. Wire rope made of flexible steel that is used to operate the control surfaces.	a. Push-pull rod.
— 2. Used to join cable ends and adjust cable tension.	b. Pulley.
— 3. Used to quickly disconnect and reconnect to the cable system.	c. Fair lead.
— 4. Will change cable direction, angle of pull and allow cable to clear obstacle.	d. Stops.
	e. Cables.
	f. Bellcranks and quadrants.
	g. Turnbuckles.
	h. Torque tubes.

- 5. Prevents a loss of cabin pressurization when cables are routed through pressurized areas.
- 6. Will transmit motion about an axis and change direction of force of a cable or push-pull rod.
- 7. Limits the range of movement of a control surface or unit.
- 8. Transmits torque or motion about an axis.
- 9. Transmits both push and pull motion.
- 10. Reduces cable vibration and sag.
- i. Cable quick disconnect unit.
- j. Pressure seals.
- k. Cable terminals.

3-2. Primary Flight Controls

It is very simple to change the way an automobile is heading by merely turning the steering wheel. This movement is about the vertical axis. Aircraft directional movement is around three axes—lateral, longitudinal, and vertical—and represents an unlimited number of planes of movement.

Like most self-propelled machines, an aircraft is equipped with the means (flight controls) of controlling its direction of travel. The controls operate well because of systems of cables, push-pull rods, bellcranks, or combinations of these systems. Even the latest aircraft having hydraulically actuated control surfaces are equipped with control linkages. Although they are not necessarily connected directly to the control surfaces, they do control the operation of the control surfaces.

630. Specify the constructional/operational features of a large aircraft that uses shutoff valves in the rudder system.

Larger Aircraft Flight Control Systems. Many larger types of aircraft have a means of shutting off pressure to the flight controls while in flight. This can serve many uses. One use would be if one system was to malfunction, the other system can be shut down. Another could be if the pilot wants to check the system. He can shut down one system and check the other to see if it is working properly. The system we have chosen to talk about in this discussion is the rudder boost control system. This particular rudder system, besides being able to shut off the pressure to each of its systems, also has a means of lowering the pressure to the rudder boost pack. We will see how this is done as we go along. Refer to figure 3-11 as we explain how the system works.

This particular rudder boost system is operated hydraulically by two separate hydraulic systems: booster and utility pressure. In each of these systems, you can find a shutoff valve, diverter valve, pressure reducer, relief valve and pressure transmitter. The boost pack itself consists of a booster control valve and a double-acting balanced actuating cylinder. A filter assembly with a built-in differential filter relief valve is installed in each inlet port to the boost pack. The differential filter relief valve will open when the filter becomes clogged. The manual control parts

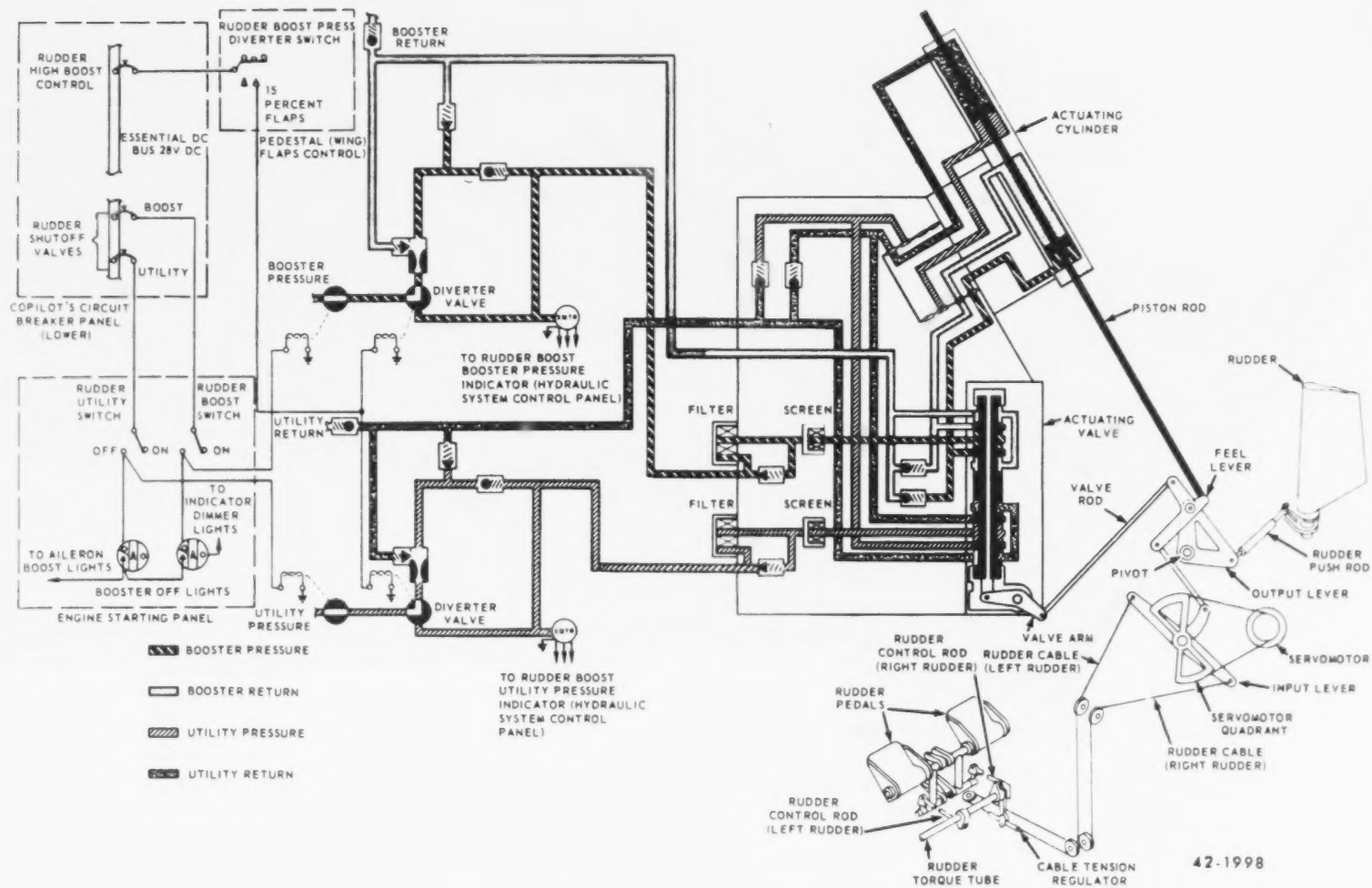


Figure 3-11. Rudder boost system.

of the rudder control system consist of rudder pedals, torque tubes, cables, tension regulator, and push rods.

Operation. With the aircraft engines running, hydraulic pressure is available to the rudder boost system. In order for pressure to flow to the boost pack, the two shutoff valves must be opened. In order to close the valves, the rudder utility switch or rudder boost switch must be moved to the OFF position. When this happens, electrical power from the rudder shutoff valves circuit breaker panel can flow to either shutoff valve, depending on which switch was actuated. Notice also that when the switch was placed to the OFF position, electrical power was available to turn on a warning light. So, anytime the shutoff valves are closed, the warning light will be on. Now let's open the shutoff valves again to allow the pressure to enter the booster and utility systems. Notice just past the shutoff valves is another valve, which is called a diverter valve (it diverts pressure). These valves are solenoid-operated, normally deenergized to allow pressure to flow through a pressure reducer. When energized, the full pressure (3000 psi) is sent to the boost pack. The diverter valves are energized by a switch on the wing flaps. Before we go on, let's explain why we want to reduce the pressure to the rudder. When the aircraft is flying at high speeds, the airload against the large surface areas of the rudder creates a tremendous force. If the rudder is forced to move against this force using 3000 psi, the rudder supporting structure could be damaged. To prevent this from happening, the rudder pressure is lowered when the aircraft is flying at high speeds. At low speeds the high pressure (3000 psi) is used to give the aircraft better maneuverability. How is this done? When the flaps are down, this either means the aircraft is taking off or landing. A switch located on the flaps will energize the diverter valve.

At this time, we have 3000 psi available to the rudder boost pack. After the flaps are raised (the aircraft is flying at a faster speed), the diverter valves are deenergized. When this happens, the pressure is diverted through the pressure reducers. The pressure reducers reduce the pressure approximately 1300 psi. Downstream from the pressure reducer is a relief valve that will open if the pressure reducer should malfunction. Notice that the pressure transmitter is installed in such a way that it transmits both the full pressure and reduced pressures to the cockpit. In figure 3-11, notice that the diverter valve is deenergized and the pressure is flowing through the pressure reducer and down to the boost pack, through the filters, and to the control valve.

Manual control. The manual part of the rudder control system consists of dual rudder pedals, torque tubes, cables, tension regulator, and a booster system (fig. 3-11). Notice that the booster system consists of control switches, a booster control valve, and actuating cylinder, and a piston rod. During normal operation, rudder boost supplies the major force to move the rudder.

Rudder control is initiated by placing the rudder switches (fig. 3-11) to ON. When these switches are

turned on, pressure from the booster and utility systems flows to the booster control valve. Pressing the pilot's or copilot's rudder pedals rotates the rudder torque tube. In turn, control cables attached to the rudder torque tube rotate an input lever. Movement of the input lever is transmitted to the booster control valve by the feel level and valve rod. When either of the left rudder pedals is moved forward, hydraulic pressure is routed through the booster control valve to the actuating cylinder. In turn, the piston in the actuating cylinder moves the rudder to the left and the aircraft turns left. Movement of the right rudder pedal forward applies hydraulic pressure, resulting in a turn to the right.

When the flight control system is operated on autopilot, electrical signals are sent to the servomotor (fig. 3-11). As the servomotor receives the signals, it positions the servomotor quadrant. It is apparent from figure 3-11 that this produces the same control effect as movement of the rudder pedals. If hydraulic pressure is lost, the rudder can be operated through mechanical force. The lost motion within the control linkages is taken up and rudder pedal movement is transmitted directly to the rudder.

Exercises (630):

1. During normal operation, what force moves the rudders?
2. Why are shutoff valves installed in the rudder boost system?
3. How does the autopilot control the rudder?
4. Why is the pressure to the rudder lowered at high air speeds?
5. How is rudder booster control initiated?
6. How are the diverter valves energized?
7. If rudder boost pressure is lost, how is the rudder operated?
8. If a warning light was on, what would this indicate?

9. If the pressure transmitter is reading 3000 psi, what position is the diverter valve?

631. Specify operational features of the flight control system.

Flight Control Systems Operation. Control of the aircraft in flight is accomplished both manually and automatically. Basic manual control is initiated by moving a control stick to position controlsurfaces. For each movement of the control stick, several actions occur. In the following paragraphs, we discuss these actions.

Lateral control operation. The lateral control system consists of two aileron power cylinders, four spoiler power cylinders, a control stick in each cockpit, two ailerons, four spoilers, two aileron dampers, two spoiler servo valves, and mechanical linkages (figure 3-12). In addition to the components shown in figure 3-12, the system contains hydraulic check valves, a hydraulic relief valve, and hydraulic filters. Notice in figure 3-12 that the lateral controls in the left wing are powered by PC-1 and utility hydraulic power. Lateral controls in the right wing are powered by PC-2 and utility hydraulic power.

Lateral movement of the control stick, figure 3-12, is transmitted mechanically by push-pull rods, through a walking beam bellcrank, to the spoiler servo valves and aileron control valves. The spoiler servo valves and aileron control valves allow hydraulic pressure to simultaneously move the spoilers and ailerons. The

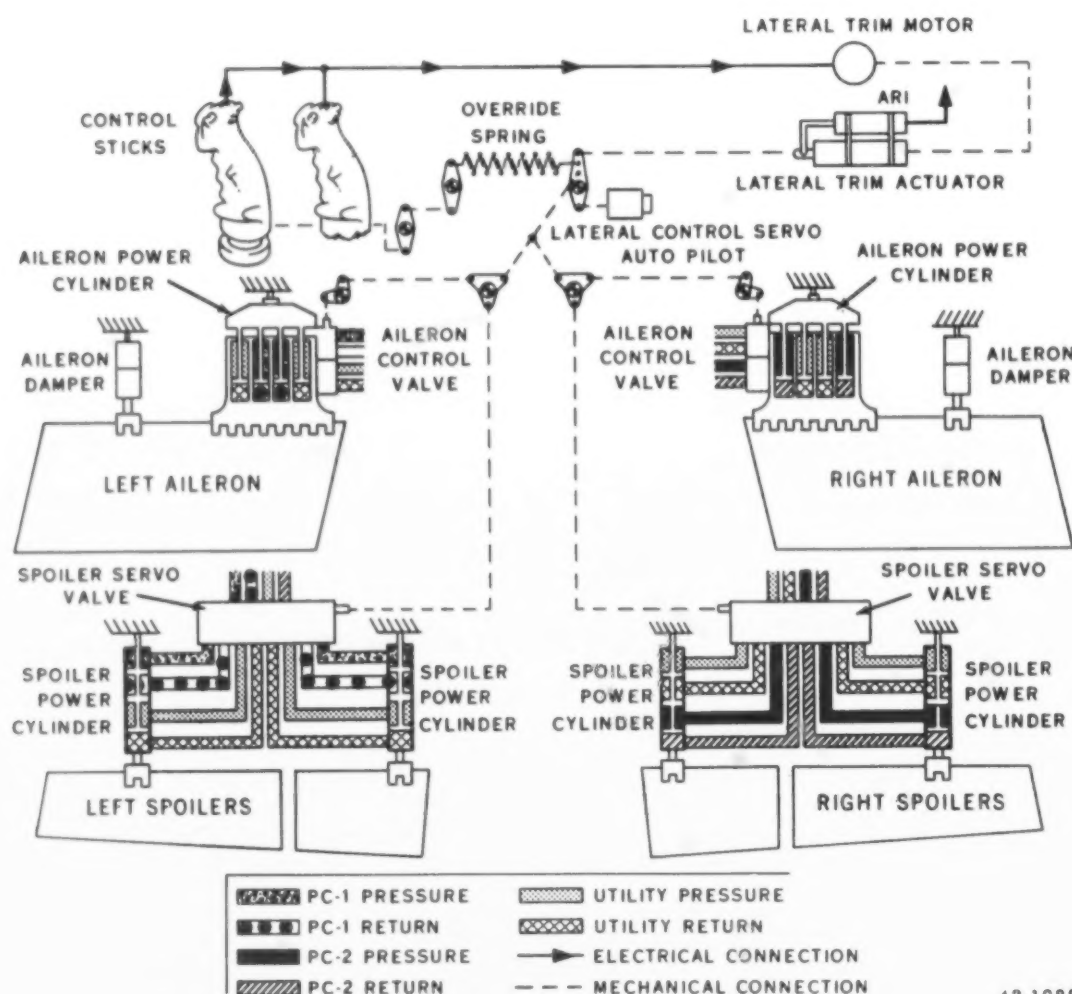


Figure 3-12. Aileron control system.

42-1988

aileron control valves and spoiler servo valves meter hydraulic fluid to the power cylinders in proportion to mechanical displacement. An overridespring, figure 3-12, is incorporated into the left and right push-pull rod system. If one side becomes jammed, the override spring deflects under force, allowing operation of the other lateral control surfaces. A self-serviced aileron damper serves as an upstop and dampens aileron flutter.

The automatic flight control system (AFCS) is an electrohydraulic system that provides stable, accurate, and coordinated flight maneuvers without interfering with manual control. It is capable of performing simultaneously in two modes of operation, stability augmentation and AFC.

The feel trim system is composed of a trim switch, a rotary power unit, two flexible drive shafts, and two jackscrew actuators. When the trim switch is energized, the rotary power unit and flexible drive shafts position the screwjack actuators. As the screwjack actuators extend and retract, the lateral controls are repositioned, and the control stick follows the trim movements. Lateral control artificial feel is provided by double-action spring cartridges connected in tandem with the screwjack actuators. When the control stick is moved from NEUTRAL, the springs are compressed. The farther the control stick is moved from NEUTRAL, the greater the force required to compress the springs. The spring cartridges return the control stick to NEUTRAL when the force on the control stick is removed.

The aileron-rudder interconnect (ARI) system causes rudder displacement proportional to aileron displacement to provide coordinated turns at low airspeeds. When the system is engaged, the ARI actuator is allowed to move the control linkage (if aileron displacement is present) and cause rudder displacement.

Stabilator operation. When the control stick is moved longitudinally, the motion is transmitted by

push-pull rods to a bellcrank. Motion is then transmitted by a cable assembly to another push-pull rod set. The second push-pull rod set actuates the stabilator control valve, figure 3-13, which meters hydraulic fluid to the power cylinder. Hydraulic pressure to the stabilator power cylinder is supplied by both power control hydraulic systems. If one system fails, the remaining system provides adequate control response.

A hydraulic AFCS servo, figure 3-13, is integrated into the stabilator control valve. This servo positions the dual servo valve in the same manner as control stick inputs. As a result, when the autopilot signals for a pitch altitude change, the control stick follows the movement.

Artificial feel is provided by a dynamic ram air bellows, figure 3-13, acting through a bob weight and through a variable bellcrank on the trim actuator. When the aircraft is in trim, the ram air force on the bellows is balanced by the bob weight. The bob weight increases stick forces so as to compensate for increase in G forces. As the aircraft increases or decreases in airspeed, the pressure on the bellows changes. This causes the bellows bob weight assembly to become off balance. The off-balance condition is then transmitted through the trim actuator, control cables, and push-pull rods back to the control stick. Then by actuating the trim switch, the stabilator trim actuator moves, balancing the forces between the bellows and the bob weight, thereby eliminating force on the control stick. An override spring cartridge allows the feel and trim portion of the stabilator control system to be bypassed in the event of noseup trim malfunction.

Rudder operation. When the rudder pedals are moved, the motion is transmitted by the push-pull rods, bellcranks, and cable assemblies to the rudder servo valve of the rudder power control cylinder, figure 3-14. The servo valve meters utility system hydraulic fluid to the power control cylinder, which positions the rudder. Should hydraulic pressure fail, the power

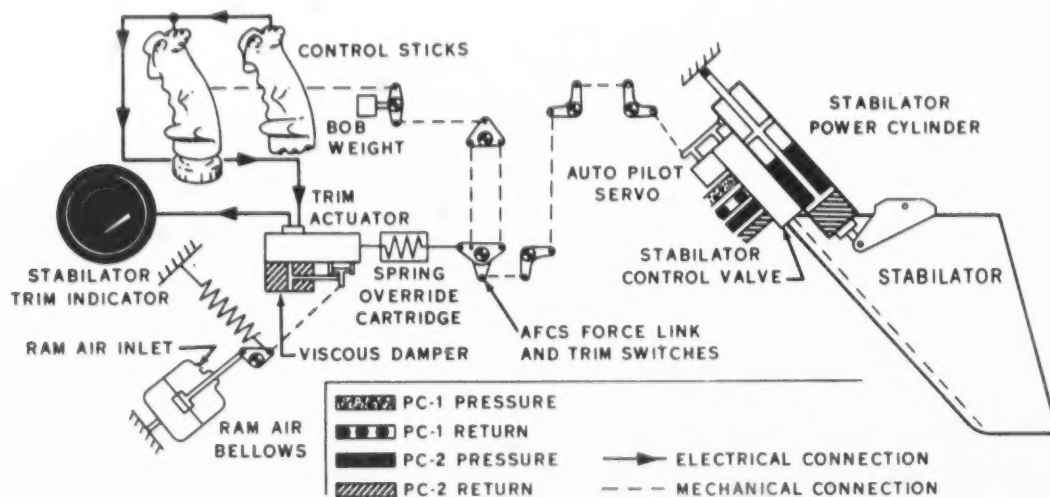


Figure 3-13. Stabilator control system.

11. In the stabilator system, what is the purpose of the stabilator control valve?

12. What is the purpose of the override spring cartridge in the stabilator system?

3-3. Secondary Flight Controls

In addition to primary flight controls, some aircraft are equipped with auxiliary (secondary) flight controls. These are mostly lift and drag devices used to give the aircraft a shorter landing and takeoff roll, to allow it to take off with greater loads, or to create additional drag to control the aircraft flight. One of the most common types of auxiliary flight controls is the wing flaps.

632. Trace the fluid flow through the flap system and specify how the asymmetry brakes are applied.

Wing Flap System Operation. The wing flap system shown in figure 3-15 shows two Fowler-type flaps that are hydraulically operated by jackscrews. This control system raises and lowers the flaps according to the movement of a control lever in the flight station. Normal operation is by utility hydraulic system pressure. Emergency operation is by a manually operated drive assembly. During normal operation, the flap lever (see fig. 3-15) provides manual control of wing flap movement. As the lever is moved between the UP and DOWN positions, it energizes a solenoid-operated wing flap selector valve. Then pressure is directed to the up or down port of the flap motor. In turn, the motor drives the torque shafts and the jackscrews are rotated in the direction necessary to raise or lower the flaps.

A hydraulic disc flap brake (see fig. 3-15) is automatically applied when movement of the flap lever and movement of the followup switch assembly in the control unit has stopped. This brake holds the flaps in position. The asymmetry brakes (fig. 3-15) mounted on the ends of the torque shaft hold the flaps in position at the instant the right and left shaft ends reach a dangerous unsynchronized condition. Asymmetric sensing switches are part of each asymmetry brake. Out-of-symmetry closes the electrical circuit through a switch in the LH brake and a switch in the RH brake. As the circuit energizes, the emergency flap brake valve repositions to divert fluid from the flap motor to the asymmetry brakes. If the flaps are not stopped, it could cause a violent roll of the aircraft. Now, the flaps cannot be operated until the electrical power is disconnected from the emergency flap brake valve, and the manual release latch on the valve is actuated. With power

disconnected and the latch pulled, the emergency flap brake valve returns to the normal position. If hydraulic pressure is lost, the flaps are operated manually.

Exercise (632):

1. What causes the asymmetry brake system to be applied?

2. How are the flaps operated in emergency?

3. What holds the flaps in the desired position?

4. What hydraulic valve will the flap lever energize?

5. To what component is hydraulic pressure from the flap selector valve directed?

633. Trace the fluid flow through the flap system and specify the procedures for raising and lowering the flaps.

Raising and Lowering Flaps. Normal operation of the flap system, as shown in foldout 9, is controlled by a switch in the forward cockpit. This switch has three positions—UP, 1/2, and DN. When the switch is placed in the 1/2 DOWN position, the selector valve allows utility hydraulic pressure to flow through the shuttle valves and into the down side of the leading edge (LE) flap actuating cylinders. In turn, the leading edge flaps move to the FULL DOWN position. At the same time, hydraulic fluid flows through the flow divider and into the trailing edge (TE) actuating cylinder, moving the TE flaps to the 1/2 DOWN position.

Movement of the flap control switch to DN allows hydraulic fluid to flow through the selector valve through flow divider and into the down sides of the TE flap actuating cylinder. In turn, the TE flaps move from 1/2 to the FULL DOWN position.

Movement of the flap control switch to UP allows hydraulic fluid to flow through the selector valve through the flow divider and to the LE and TE flap actuating cylinders. In turn, the flaps return to the FULL UP position. When the TE flaps begin to move up, the UP indicator light will come on. When the flaps are FULL UP, the electrical control circuits and the solenoids on both selector valves are deenergized.

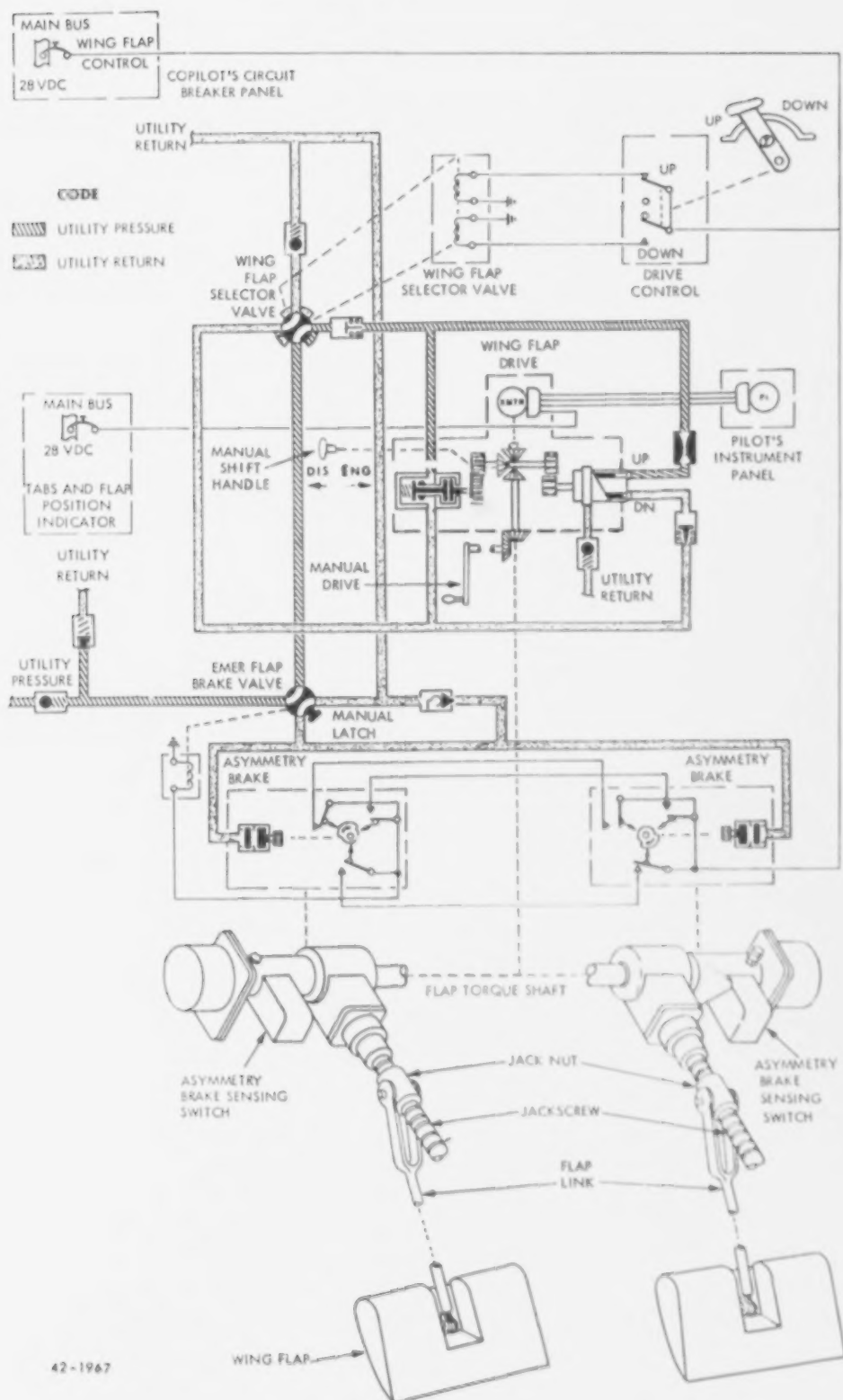


Figure 3-15. Wing flap system.

In case of electrical or hydraulic power failure, emergency flap extension is provided by high-pressure air from an air bottle charged to 3000 psi. When the flap control handle (forward or aft cockpit) is pulled, the piston inside the air selector valve is shifted. This allows high-pressure air to flow through a separate set of lines to the down side of the actuating cylinders. As the LE and TE flaps extend, the dump valve opens to dump return hydraulic fluid overboard.

The flap blowup switch will automatically raise the flaps if the airspeed exceeds a certain amount.

Exercises (633):

1. When the switch is placed in the 1/2 position, through what components will hydraulic fluid flow to lower the TE flaps to the 1/2 DOWN position?
2. What happens to hydraulic fluid when the dump valve is positioned during emergency operation?
3. What slows the speed of the leading edge flaps?
4. What position will the flaps move to when the emergency system is used?
5. To what components will hydraulic fluid from selector valve 2 flow?
6. When the flap control switch is moved to the UP position, through what components will hydraulic fluid flow to raise the flaps?

6-4. Flight Control System Maintenance

Maintenance is the name of the game; as pneudraulic systems mechanics, this is what should concern you. Flight control systems maintenance includes operational checks, removal and replacement of components, inspection of the system and components, and bench checking and repairing the flight control system components. Because the coverage of the multitude of aircraft and components associated with flight control systems is beyond the scope of this CDC, the information presented on these areas in this section will be general in nature. It is advisable to follow TO procedures for performing maintenance on specific aircraft flight control systems.

634. Specify the purpose of inspecting specific items of the flight control systems and the general equipment, procedures, and safety precautions associated with an operational check.

Flight Control System Inspection. Begin the inspection with the controls in the cockpit, because all controls are connected there. Remove all access panels that cover any part of the control system. Go over the full length of the cable to see if an excessive number of wires are broken. Check the cable carefully where it passes over pulleys or through fairleads, since these are points where breaks most often occur.

Carefully inspect for corrosion and badly worn spots. Adjust the cable tension if necessary by adjusting at turnbuckles. Check the turnbuckles for proper safetying, for number of exposed terminal threads, and for cracks in the barrel. Check the pulleys for cracks and wear. If there is any indication of weakness of any kind, replace the pulley or the mount, or both.

Examine the fairleads, pressure seals, and guides for binding, wear, and corrosion. Check all units for cracks and bends. Check the hinges connecting the control surfaces to the aircraft. They should operate freely but should never be loose.

Inspect the hydraulic components for security, proper installation, and leakage. Many hydraulic components have allowable leakage rates, so be sure to check the applicable TO for the leakage rate. In the past, hydraulic units have been replaced simply because they had a drop of fluid hanging from a fitting. The way to determine if a component is leaking is to perform an operational check.

Flight Control Systems Operational Checks. Briefly, the operational check is checking to see that the control surface goes to the right position when you move the control device in the cockpit. It also checks for leaks, binding, security or any other malfunction. This check includes the indicator and lights used to give the pilot an indication of the position of the control surface. For specific inspection items and tolerances, always refer to the applicable -6 technical order.

Equipment. Selection of equipment for performing operational checks of flight controls depends, of course, upon the type aircraft. Generally speaking though, it consists of a hydraulic test stand, a generator set, or suitable substitute.

Procedures. Before performing an operational check, ascertain that the control system rigging is in good condition. Next install a template.

Templates are patterns or guides used, among other things, to measure the travel of control surfaces on aircraft. Usually made of metal, they are inserted between the movable and a stationary surface, as illustrated in figure 3-16. The template is made so that when inserted, it will fit snugly on the stationary surface with a zero mark that is aligned with the neutral position of the movable surface. Sometimes, the template is clamped in this position if it is not possible to secure a snug fit otherwise.

The face of the template is marked off in degrees from both sides of the ZERO position. When the template is inserted or fitted in place, travel of the control surface in both directions can be measured by moving the surface to its extreme limit of travel, reading from zero to the right (or left), then to the opposite extreme, and by reading and recording the figures on the template at each extreme. Most templates are made for a particular aircraft; for this reason, you must use care in selecting the correct template for a particular job. The -2 technical order for the aircraft concerned contains the correct surface travel in both degrees and inches.

Safety. Safety precautions must be observed at all times around the aircraft, and it is never more necessary than while you are operating or working around the flight controls. Never operate a control surface unless you have first cleared it. Never work on a control unless you have first immobilized it. There have been several persons killed and many injured because of the failure to properly clear a flight control before actuating it. There have been accidents due to people having their hands in the control linkages when movement occurs.

Exercises (634):

1. What does the operational check of the flight controls normally consist of?
2. What are the two main pieces of support equipment you will be using to operationally check flight controls?
3. Other than determining their conditions, which safety precaution should you observe before moving the controls?
4. Why must the cable be inspected carefully where it passes over pulleys or through fairleads?
5. What would be done if weakness was detected in a pulley on inspection?
6. Why is a template used during an operational check?
7. Why must the applicable aircraft TO be checked for component fluid leakage rates?
8. Can any template be used on any aircraft? Explain your answer.

635. Name the source for instructions for removal and installation of flight control components, and specify procedures applicable to the removal, installation, bench check, and repair of flight control system components.

Flight Control Removal and Installation. From time to time, units in the flight control system must be removed, replaced, adjusted, operationally checked, cleaned, or lubricated. The applicable organizational maintenance manual lists specific procedures that must be followed.

Because of the mechanical linkage involved, normal use will require some adjustments. When inspections indicate the need, it becomes necessary to rig and adjust the mechanical linkage in the flight control system.

Removal procedures. Removal procedures differ from component to component in the flight control system, so we do not go into a detailed explanation of removal. However, the details of removal and installation have some similarities. These are:

- Assemble the tools and equipment for removal.
- Insure that hydraulic and electrical power are removed from the aircraft.
- Relieve hydraulic pressure.
- Disconnect hydraulic lines or hoses from component being removed.
- When hydraulic lines or hoses are disconnected, tag them while disconnecting to prevent cross-connection during installation.

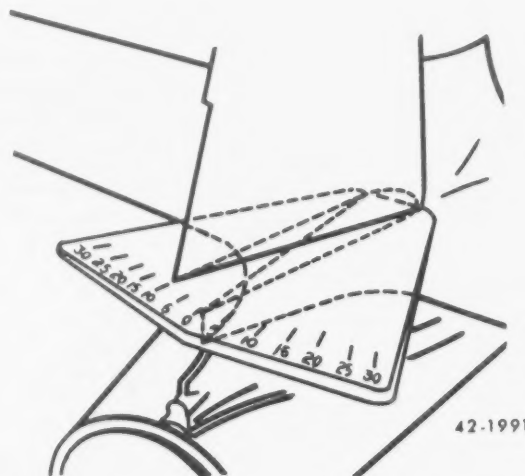


Figure 3-16. Flight control template.

- Cap the lines and hoses to prevent contamination from entering the system.
- Disconnect mechanical linkage to control valve.
- Remove mount bolts.

Bench check and repair off flight control components. Because the flight controls components are so critical, most of the power control cylinders cannot be bench checked or repaired properly at base level. You can check them for external leakage, but this, of course, will depend on -6 technical order. Simple shutoff valves, fittings, restrictions, etc. can be bench checked and repaired within the capabilities of the shop and -6 limitations.

Installation procedures. Installation procedures, like removal, vary from component to component. The most important single point to remember when installing components is to read each step of the technical order individually. Then, insure the step is complied with. This is especially true concerning the NOTES, CAUTIONS, and WARNINGS. Though the procedures vary, some main points remain fairly constant.

The installation will usually require that you perform an inspection of the units to which you will be attaching the serviceable component. Check for proper adjustment of the hydraulic cylinder and/or rigging. You must assure proper torque has been applied. Lubricate the specified points and, finally, check for proper operation.

Safety precaution. Safety must never be ignored while working around aircraft. This is one very important aspect of flight control maintenance that cannot be overstressed. Always assure the controls are clear before applying hydraulic pressure to the aircraft to prevent injury to personnel.

Exercises (635):

1. Where can you locate the procedures for removing flight control system components?
2. What is the final step in the installation procedure?
3. Why should hydraulic lines be tagged before disconnecting them from a unit?
4. What determines whether simple shutoff valves and restrictors can be bench checked and repaired by the pneudraulic shop?
5. What is the most important single point to remember when installing a flight control system component?
6. What can be done during removal of a component to insure that dust or dirt will not enter the hydraulic system?

In Flight Refueling System

ON 12 NOVEMBER 1921, Wesley May, with a 5-gallon can of gasoline strapped to his back, climbed from the wing of a Lincoln Standard flown by Frank Hawks to the wing skid of a Curtiss JN-40 piloted by Earl Daugherty. He slowly made his way to the engine and poured gasoline into the tank. The era of inflight refueling had begun.

The Air Force became interested in this new technique and, during the years that followed, took steps to develop it. Finally, on 1 September 1953, information was released about the first inflight refueling of jet-powered aircraft. A B-47 Stratojet had received fuel in the air from a KB-47B.

A year later, between 17 and 19 November 1954, a USAF B-47 Stratojet bomber broke all existing jet endurance records by shuttling nonstop between England and North Africa in 47 hours, 35 minutes. Inflight refueling made this 21,000-mile flight possible.

A few years later, on 18 January 1957, three B-52 Stratofortresses commanded by Major General Archie J. Old, Jr., USAF, completed a 24,325-mile, round-the-world, nonstop flight in the record time of 45 hours, 19 minutes. The average speed was 534 mph. This was the first globe-circling nonstop flight by jet aircraft. Once again, inflight refueling techniques made this flight a reality. The era of ultra-long range flight had begun.

Not to be left out of the picture, on 2 December 1964, four F4C Phantom jet fighters performed another amazing inflight refueling feat. These supersonic, high-altitude jets completed a nonstop, 18-hour flight

of 10,000 miles, averaging 555 mph. The tankers used were KC-135s.

We have come a long way from the days of the Lincoln Standard. Today, because of inflight refueling advancements, our aircraft can reach the farthest points in the world. AS A PNEUDRAULIC system mechanic, you are responsible for the maintenance of the air refueling (A/R) system. To maintain this system, you must be familiar with the construction, operation, repair, and servicing of the units in the system. This chapter provides the knowledge that you need to perform these tasks and is devoted to the inflight refueling (A/R) systems found on a tanker aircraft and the air refueling receiver (A/RR) system.

4-1. Air Refueling System

The A/R system provides a means of transferring fuel from a tanker airplane to a receiver airplane while in flight. The boom is equipped with a nozzle for automatic attachment to the receptacle installed on the receiver airplane. See figure 4-1.

To operate properly, the A/R system is comprised of several other systems, the hydraulic, electrical, and fuel systems. In this section we will talk about the boom operators compartment, the A/R exterior lighting system, fuel feed system, hydraulic systems, and the A/R signal system.

636. Identify the controls on the boom operator's compartment and specify their operation/purpose.

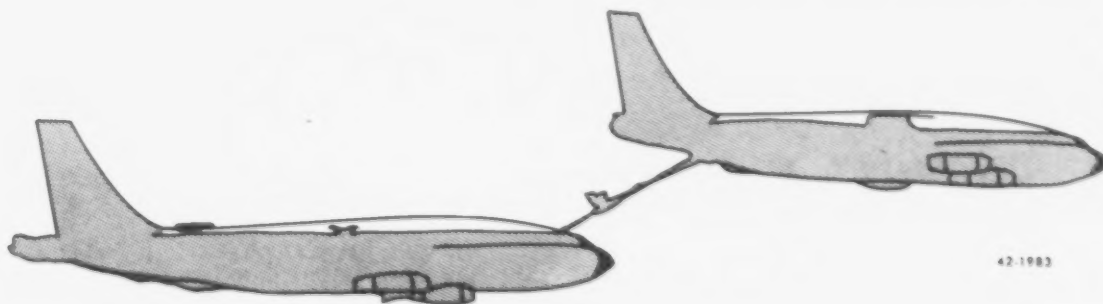


Figure 4-1. Inflight refueling.

When you are performing maintenance on various air refueling units, you may need to operate the unit or the system in which the unit functions. Therefore, you should be familiar with all of the units within the boom operator's station, such as the compartment, the boom hoist lever, the boom telescope lever, and the ruddevator control stick.

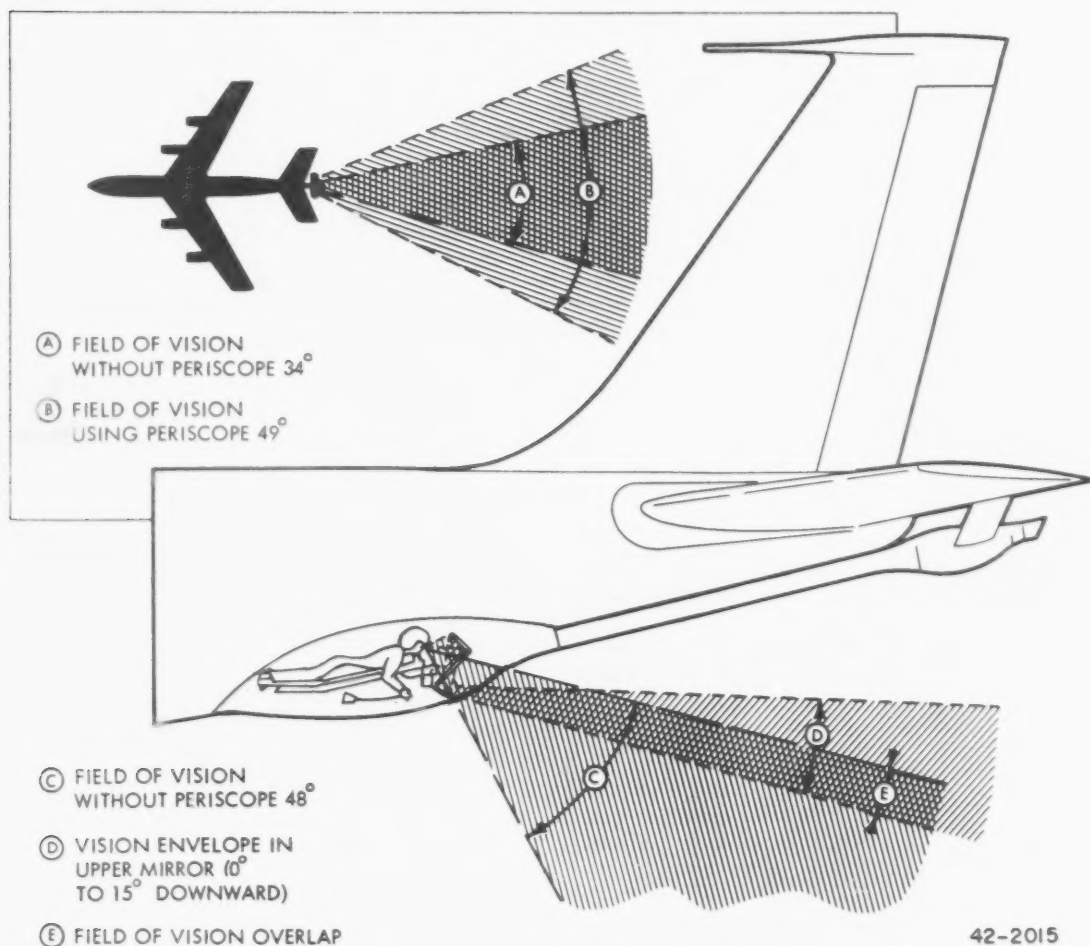
Notice in figure 4-2 that the boom operator lies on a pallet facing aft. The boom operator's periscope is installed to provide the boom operator with a large field of vision aft of the aircraft. Notice also that the boom operator has his right hand on the ruddevator control stick.

Boom Operator's Compartment. Figure 4-3 shows a typical boom operator's compartment. This compartment houses the various controls, instruments, circuit breakers, and miscellaneous equipment that you operate, observe, or use. You may have to use these items whenever you perform ground maintenance. Study the compartment in detail.

Figure 4-3 is only a representative panel. The panel you work on may have slight variations in locations. It may also have a small communication panel on its left side. In addition, it may contain an oxygen panel; despite these variations, most will be very similar to the one in figure 4-3.

In addition to the information given in figure 4-3, we will discuss three control units as they apply to a representative A/R system. These control units are the boom hoist lever, boom telescope lever, and the ruddevator control stick. Locate these items in figure 4-3 as we discuss them.

Boom hoist lever. The A/R boom hoist lever is located on the left side of the boom operator, outboard of the boom position instruments. The lever has a guarded **FREE WHEEL** position, which allows the boom to be flown aerodynamically by positioning the ruddevators with the ruddevator control stick. When the hoist lever is positioned to **HOLD**, the boom remains in a fixed position. When the hoist lever is



42-2015

Figure 4-2. Position of boom operator.

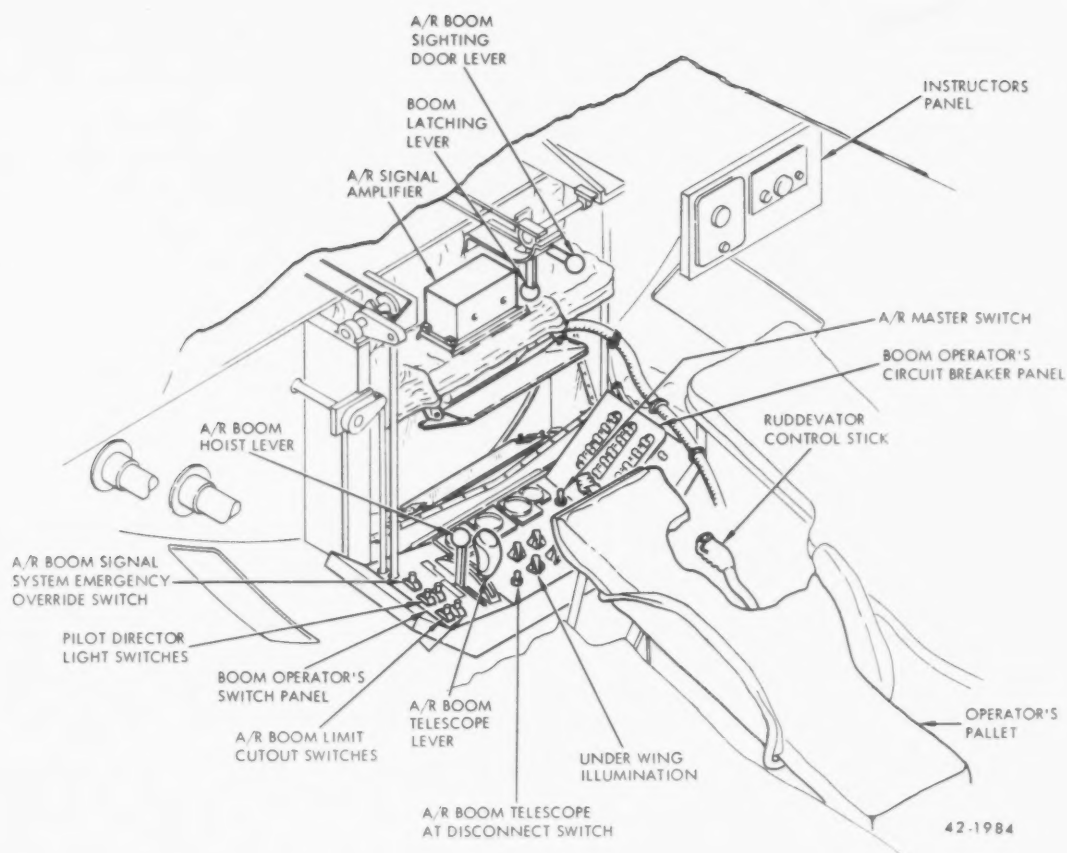


Figure 4-3. Boom operator's compartment.

positioned to either LOWER or RAISE, the rate of hoisting or lowering depends upon how far the lever is advanced.

Boom telescope lever. The A/R boom telescope lever is located on the left side of the boom operator, outboard of the boom position instruments. When this lever is advanced to either side of the NEUTRAL position, it controls the rate of telescoping of the boom. The lever is spring-loaded to the NEUTRAL position by a bungee assembly located in the sighting door compartment. Advancing the lever aft extends the boom, while pulling it forward retracts the boom. During contact MADE, the lever is in the NEUTRAL position. The telescope lever has a thumb switch, that controls the pilot director lights. When pressed momentarily by the boom operator, this switch flashes the lights as a breakaway signal to the receiver airplane.

Ruddevator control stick. The ruddevator control stick is located to right (when the boom operator is in position for refueling) and slightly below him. The control stick rotates the ruddevators to position the boom in flight. When this stick is rotated upward, it raises the boom in elevation. When rotated downward, it lowers the boom. Sideway rotation of the control stick moves the boom in azimuth. The control stick contains

two thumb switches and a trigger switch. The thumb switches are the interphone and microphone switches. The trigger switch is the A/R disconnect switch.

Exercises (636):

Match the controls in the column A with its operation/purpose the column B. Some of the controls in column B can be used more than once.

Column A Control Operation/Purpose	Column B Controls
1. Used to extend and retract the boom.	a. Boom hoist lever.
2. Used to fly the boom.	b. Boom telescope lever.
3. Has four positions, raise, lower, hold and free wheel.	c. Ruddevator control stick.
4. Moves the boom in Azimuth.	
5. Has a switch that can be used for disconnect.	

637. Specify the construction and operation of the A/R boom.

The Air Refueling Boom. The A/R boom is a telescoping tube. Figure 4-4 is a simplified drawing of the A/R boom. Notice that the boom consists of two telescopic tube assemblies (3 and 7), referred to as an outer structural tube and an inner structural tube, that connect to the A/R fuel system through a flexible fuel coupling (2). The boom is telescoped with a sprocket-driven chain (12) and cable (10), which are attached to the inner structural tube. The sprocket is driven by a reversible hydraulic telescope motor (6) through a reduction gear telescope drive assembly (8). The boom is approximately 27 feet 8 inches long when retracted, and approximately 47 feet 3 inches when extended. The inner fuel tube (14) extends approximately five-sixths of the way from the terminal end of the boom through the outer structural tube. The outer surface of the inner fuel tube forms a sliding seal, with Teflon ring seals at the forward end of the inner structural tube. The ring spring assembly (15) cushions the inner structural tube when it reaches either limit of its travel. Not to be confused with the ring spring assembly is the shock absorber recoil assembly (16). This boom component attaches the nozzle to the boom inner structural tube and absorbs impact during refueling contact. Two tandem-mounted surge boots (11 and 13) connect between the outer fuel tube (5) and the shock absorber recoil assembly. The boots are inflated with dry air to absorb high fuel pressure surges that occur during refueling or while disconnecting from the receiver aircraft. Mounted at the forward end of the outer structural tube are elevation and telescoping electrical control units (not shown). These control units actuate limit and director light switches. These control unit switches are discussed in a following objective.

The entire length of the outer structural tube mounts hydraulic lines for a fuel dump (jettison) actuator (17) and the ruddervator power controls (not shown). A ruddervator lock system, boom latch eye, and boom stowage shock absorber (9) are also mounted on the outer structural tube. Two roller brackets, each of which contains four rollers, are installed on the outer structural tube. One bracket is approximately three-fourths of the way down the tube. The outer bracket is installed at the aft end. These rollers center and support the inner structural tube and provide minimum friction during telescoping. The entire length of the boom is inclosed in streamlined fairing. The gland seal (4) prevents leakage between the inner fuel tube and outer fuel tube.

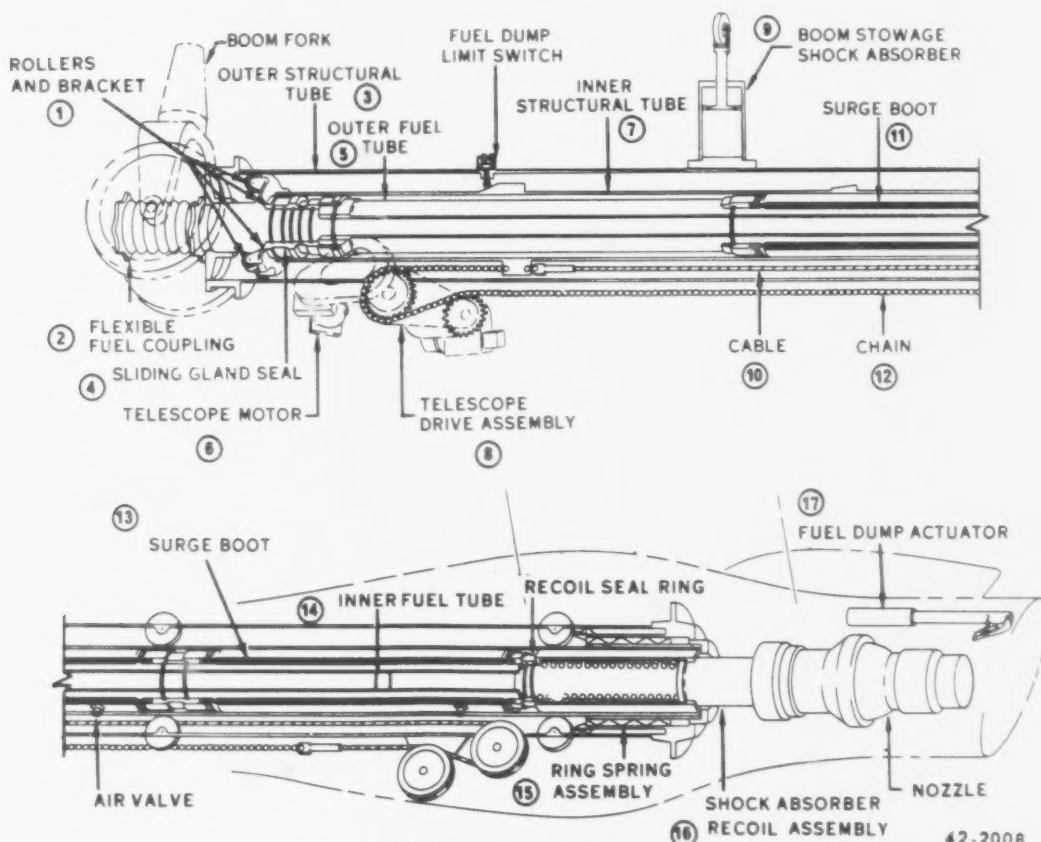


Figure 4-4. Typical A/R boom.

42-2008

Exercises (637):

1. What component of the boom cushions the inner structural tube when it reaches its limit of travel?
2. What is used to absorb fuel pressure surges in the boom?
3. What do the roller brackets do?
4. What causes the inner structural tube to telescope?
5. What prevents leakage between the inner and outer fuel tube?

638. Specify how the receiver pilot and boom operator can tell if the aircraft are positioned properly for in-flight refueling.

A/R Exterior Lighting System. The receiver pilot director lights and the boom and nozzle marker lights aid the receiver pilot in positioning his aircraft within the safe operating limits of the boom.

Receiver pilot director light system. As we have stated, limit switches in the boom A/R signal system

elevation and telescoping control units are connected in the director light circuit. These limit switches turn off or turn on a light or combination of lights in the director light circuit. The result is that the director lights on the underside of the fuselage indicate striped green, green, or red as the boom is positioned. Now look at figure 4-5. This figure illustrates a typical receiver pilot director light system. Observe that the elevation lights consist of five panels with striped green, green, and red colors, and two illuminated letters "D" and "U," for down and up respectively. These letters are at the ends of the row of lights and are on their sides. Now observe the telescoping lights. Note that the colored panels are separated by illuminated white panels. Also note the illuminated letters "A" for aft and "F" for forward, which are at the ends of the row of telescoping lights. (There are no lights for azimuth position.)

When the receiver aircraft is positioned within the red minimum limits of the boom envelope, the receiver and tanker aircraft can make contact (or maintain contact). When the receiver aircraft is attached to the tanker aircraft for in-flight refueling, the receiver pilot has to pay particular attention to the director lights. As an example, if the receiver aircraft drops too far behind the tanker aircraft, the "F" for forward director light will come on. When this happens, the receiver pilot must increase the speed of his aircraft.

Boom nozzle and marker lights. Boom nozzle and marker lights are mounted in the boom nozzle hood. You can see the locations of these lights in figure 4-5. The two boom marker lights are fluorescent black light lamps. Their ultraviolet rays cause the boom markings to glow during night refueling operations. As shown in figure 4-6, the outside surface of the inner structural tube has color markings. These markings are visible only when the boom is extended. They indicate

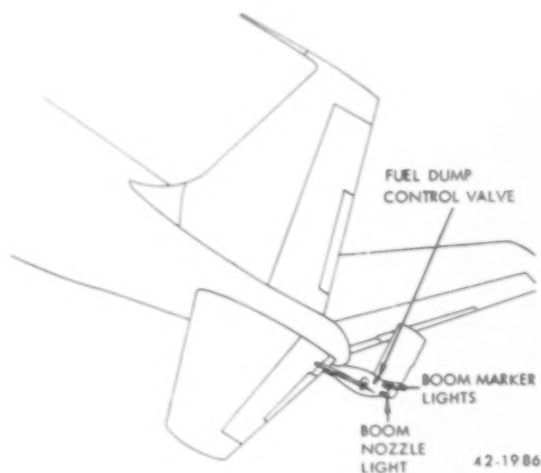
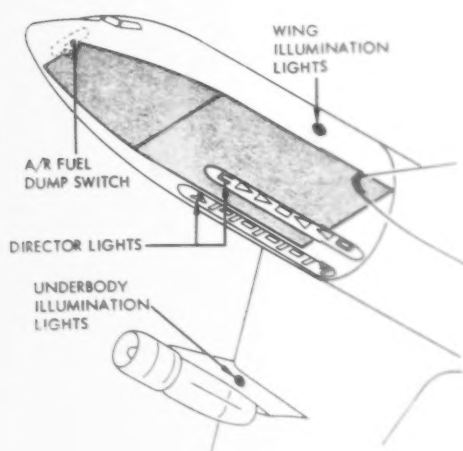
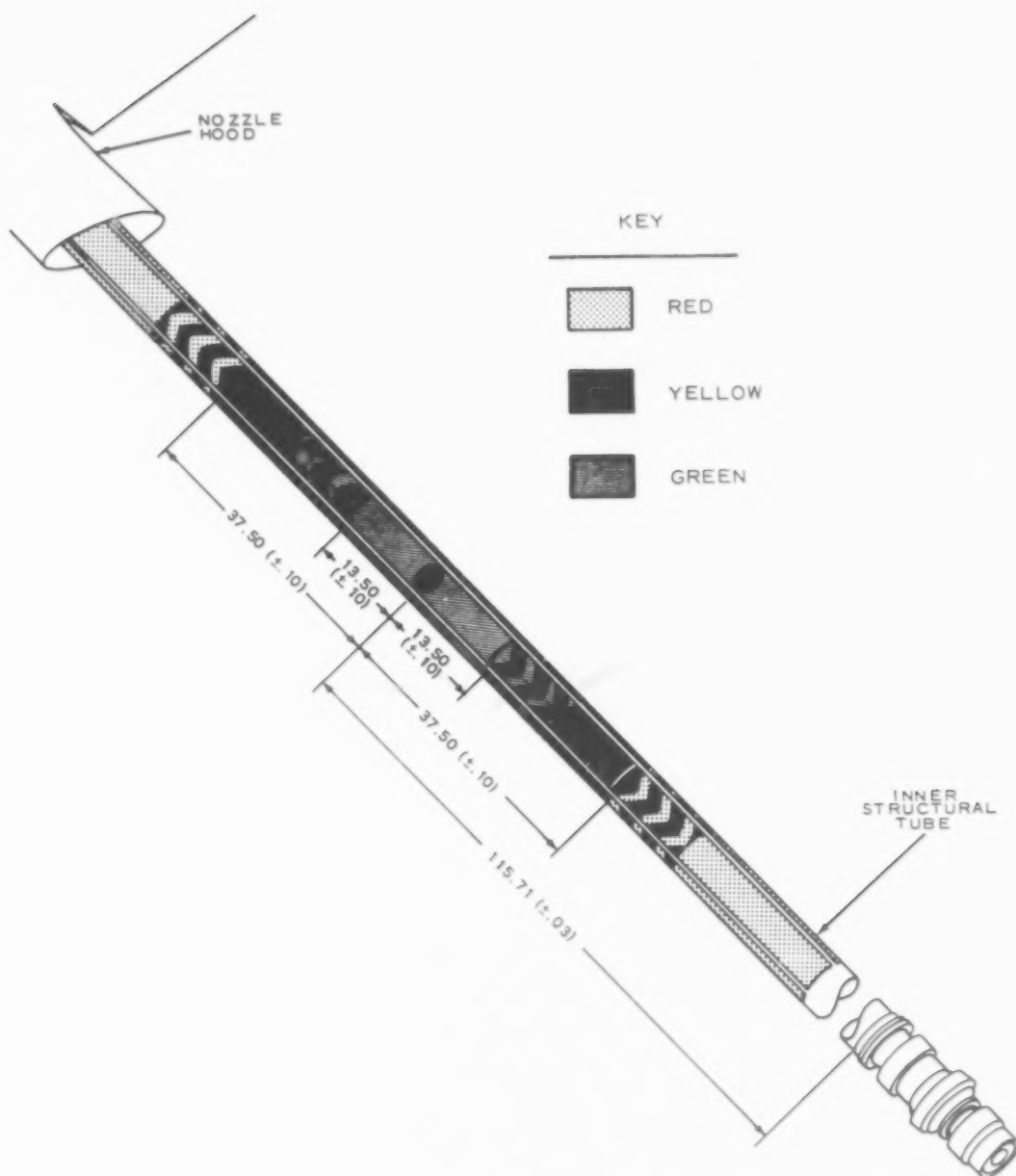


Figure 4-5. A/R exterior lights.



42-2009

Figure 4-6. Boom markings.

how far the boom is extended. During night refueling, the markings are illuminated by the boom marker lights. As the boom extends, the following markings appear: (1) solid red, (2) red and yellow chevron stripes, (3) solid yellow, (4) green and yellow chevron stripes, (5) solid green, (6) green and yellow chevron stripes, (7) solid yellow, (8) red and yellow chevron stripes, and (9) solid red. As the operator extends the boom, he can observe the markings and know how far the boom has extended.

Exercise (638):

1. If the receiver pilot moves out of the safe operating limits when hooked to a tanker aircraft, how will he know?
2. How does the boom operator know how far his boom has extended at night?

3. If a receiver pilot that is hooked up to a tanker aircraft notices a red U and A, what should the receiver pilot do?
4. How is the azimuth position indicated by the tanker pilot?

639. Describe or explain the operation of the fuel feed system and its components.

Fuel Feed System. Fuel is supplied to the fuel feed system from fuel tanks in the tanker aircraft. The main tanks and a center wing tank are located in the wings of the aircraft. A forward body tank is located in the fuselage below the cargo deck and in front of the wings. The aft body tank is located in the fuselage below the cargo deck and behind the wings.

In the following discussion, use figure 4-7 to trace the fuel flow from the fuel tanks to the boom.

When the air refueling pump switch (17) is turned on, a solenoid operated shutoff valve opens to allow hydraulic pressure to flow to the four transfer pumps (3). The pumps are driven by a hydraulic motor. When this happens, fuel for the A/R system is pumped out of the forward tank (2) and aft tank (14) into the air refueling manifold (5). Additional fuel may be transferred into these tanks from the center wing and main tanks (1 and 15) through gravity flow lines. Located between the pumps and the manifold is a check valve (4) and a low-pressure warning switch that causes a warning light to come on when the fuel pressure is low. If the line valve (8) is open, the fuel in the manifold passes through the pressure regulator (9), the flow measuring transmitter (10), and out to the boom.

Valves control fuel flow through the system. Fuel flow from the A/R manifold into the aircraft's engines is controlled by the A/R-to-engine manifold valve switch (16). The line valve (8), normally operated electrically through the A/R line valve switch (7), shuts off fuel flow to the A/R manifold and boom. The line valve also has a manual override handle (6) that can be operated to shut off fuel flow to the boom if electrical power is lost. Next, notice the automatic fuel bypass valve (13) in the A/R system. This valve enables fuel trapped in the boom at disconnect to flow back to the aft body tank. Also observe the hydraulic bypass control valve (11). This valve directs hydraulic fluid to open the bypass valve when the A/R boom is being retracted. When the A/R boom is fully retracted, the bypass valve closes. We talk more about this in the following objective.

Now, refer to foldout 10 included in the separate supplement as we discuss the following components in the boom fuel system. An A/R fuel manifold venturi (narrow portion) is located just forward of the A/R

boom. The venturi is installed in the A/R manifold to sense fuel flow. A port at the throat of the venturi senses the fuel back pressure and transmits this pressure through the A/R sensing line restrictor check valve to the fuel pressure regulator. The regulator controls the rate of fuel flow through the boom.

An A/R manifold vacuum relief valve, shown just below the A/R manifold venturi, prevents cavitation in the A/R manifold when extending the boom.

Exercises (639):

1. How is the fuel transferred from the wing tanks to the aft tanks?
2. In what compartments are the hydraulic transfer pumps installed?
3. If electrical power fails, how is fuel stopped from going to the boom?
4. Explain how fuel is pumped from the forward body tank into the boom fuel manifold.
5. What is the purpose of the A/R manifold venturi?
6. What valve enables fuel trapped in the boom at disconnect to flow to the aft body tank?
7. What valve directs hydraulic fluid to the bypass valve when the boom is being retracted?

640. State the purpose and specify the operational features of each system in the boom hydraulic system.

Boom Hydraulic System. This system performs six basic functions: (1) it opens the boom operator's sighting door, (2) hoists the refueling boom, (3) extends and retracts the boom, (4) operates the fuel bypass valves, and (5) opens the boom nozzle poppet valve during fuel dump, and (6) it furnishes pressure to the rudder power units. Let's see how the system performs these functions. As you read the text, refer to foldout 10 to locate and identify the system units.

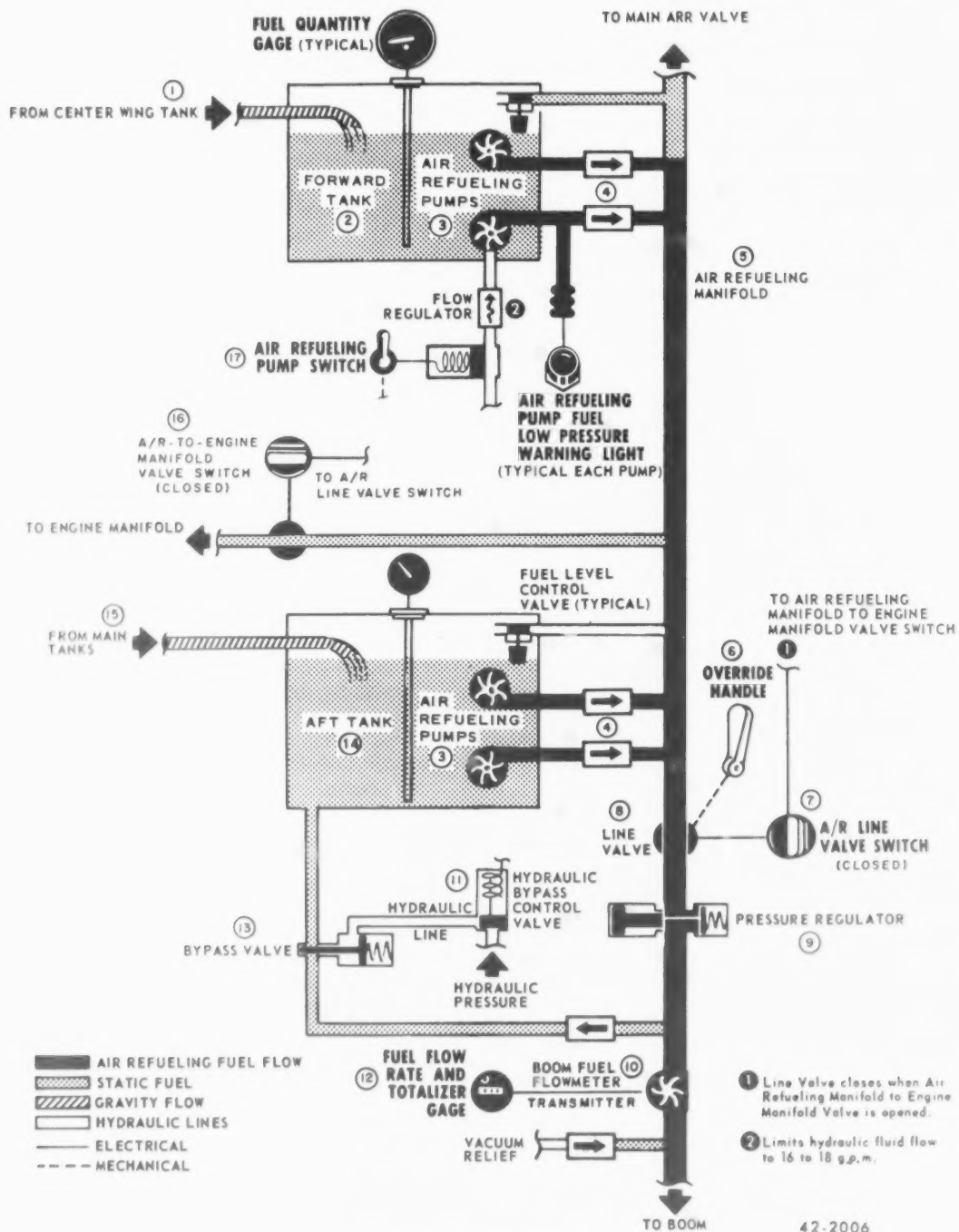


Figure 4-7. Fuel transfer system.

Sighting door. The sighting door must be open in order for the boom operator to have a full view of the boom and receiver aircraft. The door is controlled through a manually operated valve, as shown in foldout 10. Notice that the valve has a lever with OPEN and CLOSE positions. When the sighting door is closed, it provides a smooth aerodynamic surface with the aircraft skin. Also, when the valve is in the CLOSED position, it shuts off pressure to the boom hoist, tension motor, and powered rudddevators. When the control valve is placed in the OPEN position, you direct hydraulic pressure to the sighting door actuator, which lifts a locking pin and the door opens into the fuselage. When the valve is in this position, hydraulic pressure is available to all the other hydraulic subsystems.

Rudddevators. The rudddevators provide aerodynamic control of boom elevation and boom azimuth (horizontal measurement from a fixed point, clockwise, around the horizon). When the sighting door control valve is in the OPEN position, the control valve directs pressure to the rudddevator control valve and actuator. Movement of the rudddevator control stick positions the rudddevator control valve to direct hydraulic pressure to the actuator to move the rudddevators. As the rudddevators rotate, the housing of the unit, which is connected to the rudddevators, moves relative to the control valve slide. In this manner, the housing serves as the followup that allows the rudddevators to be positioned at any point within its limit of travel.

Boom hoist. The boom hoist control valve, in foldout 10, controls boom hoist motor operation when raising or lowering the boom. When you hold the boom hoist control lever to RAISE, a piston in the control valve is positioned to direct hydraulic pressure to the raise side of the boom hoist motor. At the same time, the lower side of the boom hoist motor is open to return. When you hold the boom hoist control lever to LOWER, the piston in the control valve is positioned so that the raise, lower, and return ports are interconnected. Thus, the boom lowers because of its weight. A flow regulator in the boom raise line limits the speed of the boom as it lowers. When the boom hoist control lever is in the FREE WHEEL position, system pressure is directed to both sides of the hoist motor. This equalized pressure to the motor results in a balanced condition which allows the boom to be aerodynamically flown.

You can also operate the boom hoist motor through an emergency system. During an emergency, the boom is hoisted by pressure supplied by the hand pump located to the upper right of the boom hoist control valve, as shown in foldout 10. Since there is a possibility of a hydraulic lock in the boom hoist control valve during emergency operation, position the hoist control lever to RAISE before operating the hand pump. As you can see from the diagram, hand pump pressure enters the boom hoist control valve at the emergency pressure port. This pressure moves a shuttle valve, which, in turn, directs the pressure to the raise side of the boom hoist motor. Shuttle valve movement opens the emergency return port of the control

valve; thus, hydraulic fluid returns to the emergency reservoir. The manual shutoff valve, located above and to the left of the hand pump, must be closed to build up any pressure with the hand pump.

The boom hoist unit consists of four rigidly connected assemblies; the hoist motor, cable tension motor, cable drum, and gearbox assembly. The reversible hoist motor drives a cable drum through the jaw clutch in the gearbox assembly. This causes the cable drum to rotate. During refueling, when the boom is being flown, the tension motor drives the drum to take up slack in the cable. The jaw clutch disengages the hoist motor from the cable drum if the boom is flown to the UP position faster than friction, and inertia will allow the hoist motor to turn.

Boom telescoping system. As foldout 10 shows, pressure is always available through the inflight refueling system accumulator to the boom telescope valve. Notice also that the lever for this valve has RETRACT and EXTEND positions. With the lever in the EXTEND position, hydraulic pressure is directed to the boom telescope hydraulic motor. The motor is attached to a chain and sprocket assembly that will extend the boom. When the control valve is placed in the RETRACT position, the chain and sprocket assembly retract the boom.

Fuel dump system. The fuel dump system is used to dump fuel overboard in emergency. To dump fuel, the fuel dump switch must be placed to the DUMP position. This energizes the fuel dump control valve, which directs hydraulic pressure to the fuel dump actuator. When the actuator retracts, it depresses the check valve on the boom nozzle, which will dump the fuel overboard.

Auto retract control system. Notice the auto retract control valve and the auto retract actuator just above the system accumulator in foldout 10. A telescope-at-disconnect switch controls the position of the auto retract control valve. This switch selects the control of the boom at disconnect from the receiver aircraft. In AUTO, the boom automatically retracts when the signal system (you learn more about this later) advances to DISCONNECT. In foldout 10, observe that the telescope-at-disconnect switch is in the AUTO position. Also observe that the auto retract control valve is shown denegized. In this control valve position, hydraulic pressure is directed to the bottom side of the auto retract actuator. However, whenever a DISCONNECT signal occurs or whenever the copilot actuates the fuel dump switch, the auto retract control valve is energized. In the energized position, hydraulic pressure is directed to the auto retract actuator to extend it. As the actuator extends, the boom telescope valve moves, by means of a system of linkage, to its RETRACT position. As a result, the valve automatically directs hydraulic pressure to the boom telescope motor to retract the boom, regardless of telescope control lever position.

Air refueling fuel bypass. When you position the boom telescope lever to RETRACT (with the boom extended) or when the auto retract actuator moves to

DOWN, the bypass control valve is energized. When the control valve is energized, it permits hydraulic pressure to open the air refueling fuel bypass valve. With the fuel bypass valve open excess fuel trapped within the boom during retraction flows back to the aft body tank.

Exercises (640):

1. Which systems of the boom hydraulic system are affected by closing the sighting door?
2. List the hydraulic subsystems of the boom hydraulic system.
3. How is fuel dumped overboard from the boom nozzle?
4. What is the purpose of the air refueling fuel bypass system?
5. To what system will hydraulic pressure be applied when the sighting door control valve is in the OPEN position?
6. What is the purpose of the ruddervators?
7. What happens when the ruddervator control stick is moved?
8. What does the tension motor do?
9. In what position is the boom hoist control valve when the raise, lower, and return ports are interconnected?

641. Specify the construction and operational features of the A/R signal system.

A/R Signal System. The A/R tanker signal system operates in conjunction with the receiver signal system

to automatically control the hydraulic and fuel systems for READY, MADE, and DISCONNECT conditions. Signals originating in either signal system are transmitted to the other system through signal coils in the bottom nozzle and nozzle receptacle. The complete signal system consists of a signal control amplifier, signal coil, boom telescope control unit, boom elevation control unit, and boom azimuth control unit. Position indicators on the boom operator's instrument panel indicate the boom position relative to the tanker aircraft. Other indicator lights show the current condition of the system. Limit switches in the electrical control units operate to automatically disconnect the boom whenever it goes outside the operating envelope limits.

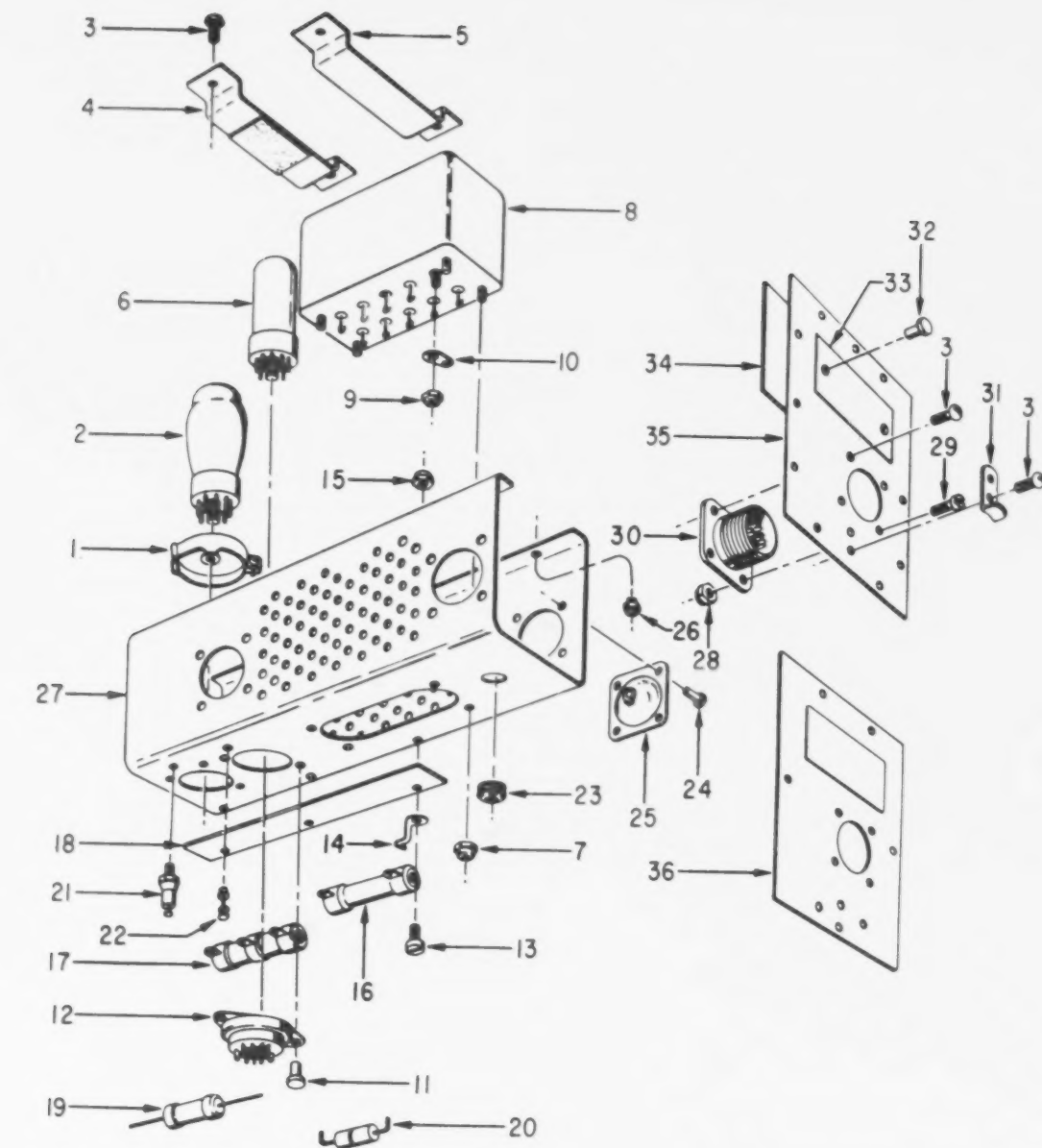
Signal amplifier. The signal amplifier, shown in figure 4-8, contains a thyratron tube and six multiple contact relays. It is the nerve center of the signal system. An electrical impulse from any boom limit switch, from the receiver through the signal coil, or from the boom operator's disconnect switch on the ruddervator control stick causes the thyratron tube to conduct. Since the tube is connected in series with the relay circuits, its conduction actuates certain relays to complete circuits between amplifier connector pins during refueling READY, MADE, and DISCONNECT conditions.

A/R signal coil. The signal coil is an inductive-type coil located in the nozzle of the boom. This coil mates with a similar coil in the receiver receptacle to transfer the various signals from one aircraft to the other. The coil is wound in a plastic block fastened on the lower side of the nozzle.

A/R signal system operation. The signal system is placed in the READY condition by placing the A/R master switch to ON. When the switch is turned on, the following conditions are established—power is supplied to pin A of the signal amplifier, which is shown in foldout 10, and the ready indicator light comes on through pin C of the signal amplifier.

Next, when the boom extends and contact is made with the receiver aircraft, the boom nozzle actuates a switch in the receiver receptacle. Actuation of the switch sends a MADE signal through the signal coil in the receptacle to pin F of the signal amplifier. This signal actuates the signal amplifier, which performs the following functions: energizes the made relay, illuminates the made light, and applies power to the operating envelope limit switches. The aircraft is now able to transfer fuel from the tanker aircraft to the receiver aircraft. If, for any reason, the aircraft needs to be disconnected, a disconnect signal must be initiated.

The DISCONNECT signal may come from any one of the following sources—the azimuth, telescoping, or elevation limit switches—if the amplifier override switch is in the NORMAL position. In other words, if the receiver aircraft goes out of reach of the boom limits, the boom switches will automatically cause a disconnect. Disconnect signals may also come from the boom operator's disconnect switch or from the receiver



- | | | |
|---------------------|--------------------------|---------------------|
| 1. Clamp Tube | 13. Screw | 25. Vibration Mount |
| 2. Tube, V1 | 14. C lamp | 26. Nut |
| 3. Screw | 15. Nut | 27. Chassis |
| 4. Bracket Assembly | 16. Resistor, Fixed, R1 | 28. Nut |
| 5. Bracket Assembly | 17. Resistor, Adj., R1 | 29. Screw |
| 6. Tube, V2 | 18. Plate | 30. Connector |
| 7. Nut | 19. Capacitor, C1 | 31. Hook |
| 8. Relay K1 | 20. Resistor, R2, R3, R4 | 32. Rivet |
| 9. Nut | 21. Terminal | 33. Nameplate |
| 10. Terminal | 22. Terminal | 34. Wiring Diagram |
| 11. Rivet | 23. Grommet | 35. Panel |
| 12. Socket, Tube | 24. Rivet | 36. Panel |

Figure 4-8. Signal amplifier.

42-2012

signal system through the signal coil. After a disconnect signal is received and the telescope-at-disconnect switch is in the AUTO position, the following operations occur: (1) the disconnect light illuminates; (2) a signal is sent to the receiver aircraft (unless the disconnect signal originates in the receiver); (3) the made relay is deenergized; (4) the fuel bypass control valve is energized through the fuel dump limit switch; (5) power is removed from the boom operating envelope limit switches; and (6) the auto retract valve is energized.

Fuel dump control circuit. Actuation of the fuel dump switch, shown in foldout 10, to FUEL DUMP overrides the A/R signal system. It also energizes the pump control relay and fuel dump relay. If the boom is extended, the auto retract control valve and fuel bypass control valve are energized through the fuel dump limit switch and fuel dump relay. When energized, these two valves open the fuel bypass valve and retract the boom (but do not stow it). As the boom reaches within 7 inches of full retract, a dump limit switch in the boom is actuated. This limit switch actuates the A/R dump control valve. The A/R dump control valve applies power to the fuel dump actuator to depress the poppet valve in the boom nozzle. At the same time, power is directed through the energized pump control relay to operate the A/R pump. (When fuel dumping is completed, the A/R pump is turned off with the A/R pump switch.) If normal electrical power fails, battery power can be selected to dump fuel in emergency situations.

Exercises (641):

1. How are electrical signals transferred from one aircraft to another during hook up?
2. When power is turned on, what position light should come on?
3. If the receiver pilot moves out of the envelope, what will automatically happen?
4. How far, within full retract, must the boom reach before the fuel dump limit switch in the boom is actuated?
5. List at least three ways that a disconnect signal can be initiated.

4-2. Air Refueling Receiver System

The air refueling receiver system is installed on aircraft to provide additional load and distance capabilities. The air refueling receiver system, as covered in this section, is referred to as the air refueling receiver, with an abbreviation of "ARR." The ARR system includes the slipway doors air refueling receiver receptacle, fuel manifold system, hydraulic system, and electrical system. These systems operate, control, and give indications of operation. In this section we talk about the construction and operation of these systems.

642. Specify the constructional and operational features of the air refueling receiver system.

Construction of the ARR System. On a representative aircraft, two hydraulically operated slipway doors are located on top of the fuselage, as shown aft of the pilot's compartment. When the slipway doors are open, they provide an entrance to the ARR receptacle. Let's talk about the three systems (fuel, hydraulic, and electrical) that make up this ARR system.

Fuel system. The first item in the fuel system is the receptacle itself. This item serves as an interconnect between the tanker boom and the receiver manifolds. See figure 4-9. It is basically a quick disconnect, acting as the female half while the boom nozzle is the male half. The ARR fuel manifold is a 4-inch fuel tube that connects the ARR receptacle to the main fuel valve. Located in the fuel tube is a pressure switch that senses the amount of fuel pressure in the tube. The main fuel valve is a

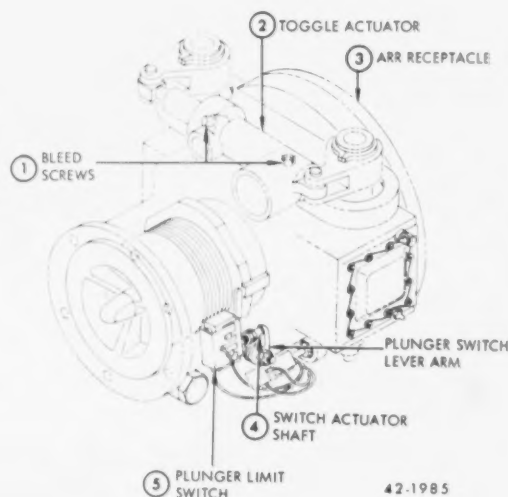


Figure 4-9. Receiver aircraft receiver.

motor operated shutoff valve. It can be operated to open or close the fuel line.

Hydraulic system. The ARR hydraulic system operates the slipway doors and the ARR receptacle toggles. It is comprised of control valves, shuttle valves, and actuators.

a. Slipway door control valve. The slipway door control valve is a solenoid-actuated hydraulic valve that controls the flow of hydraulic fluid to the slipway door actuators. This causes the slipway doors to open or close depending on which solenoid is energized.

b. Slipway door shuttle valve. The slipway door shuttle valve is located in the line between the slipway door actuator and the control valve. When the ARR slipway doors are positioned to OPEN, hydraulic pressure moves the shuttle to close off the door close line. This action allows the door close line between the shuttle valve and actuator to be pressurized. Since both the open and closed line of the actuator are pressurized, the door will open due to the larger area on the door open side of the actuator piston.

c. Slipway door actuators. Two hydraulic actuators open or close the slipway doors. When the slipway doors are closed, the piston is retracted in the actuator and locked by an internal locking mechanism. During the door open cycle, hydraulic pressure forces the piston out of the locking detent and allows the piston to extend to the DOOR OPEN position.

d. Toggle control valves. The toggle control valves are solenoid-actuated and control the flow of hydraulic fluid to the air refueling receptacle toggle actuator. When the toggle control valve is not energized, the return port is open to release pressure from the "latched" port of the toggle actuator.

e. The toggle actuator. The toggle actuator is a double-acting hydraulic cylinder mounted over the air refueling receptacle for actuation of the toggles. Arms, fastened to both the piston and cylinder ends of the actuator, rotate two shafts to which the toggles are attached. The toggle actuator piston incorporates a spring-loaded ball relief valve, which bypasses fluid from the retract side if pressure becomes excessive on the pull-away of the air refueling nozzle from the receptacle.

f. The ARR accumulator is a 25-cubic-inch capacity hydraulic accumulator. It is located in the ARR hydraulic system to absorb hydraulic surging caused by the movement of the toggle actuator during emergency breakaway. An air pressure gage on the accumulator provides a means of measuring the 1000 psi air preload or the total pressure in the accumulator.

ARR electrical system. The electrical system controls the refueling sequence and indicates to the pilot or copilot the sequence condition of the system. The system consists of a signal amplifier,

receptacle induction coil, solenoid-operated hydraulic control valves, system switches, ARR signal lights, and selected electrical wiring connecting the components.

The signal amplifier, which is the heart of the air refueling system, is actually an electronic three-position switch. Whenever an electrical signal is sent to the amplifier, it switches to the next position. The three positions and the order of sequence are READY (this is the normal position to which the signal amplifier returns when all power is removed), CONTACT, and DISCONNECT.

ARR system operation. With the master refuel switch in the ON position, the slipway doors CLOSED and LOCKED light will come on. When the normal slipway door control switch is placed in OPEN and the signal amplifier power switch is in the NORMAL position, power is supplied to the open solenoid of the normal slipway door hydraulic control valve. This causes the slipway door control valve to direct pressure to both sides and the slipway door actuators. The doors will open because of the large area on the open side of the piston. Hydraulic fluid is also admitted to the UNLATCH port of the toggle actuator, causing the piston to retract and unlatch both toggles. As the slipway doors open, DOOR CLOSED limit switches will actuate and the slipway doors CLOSED AND LOCKED light will go out. The signal amplifier, when energized, supplies voltage to the slipway DOOR OPEN limit switches, to the normally open toggle shaft limit switches, and to the normally open plunger limit switch. When the doors reach the fully OPENED position, the slipway door open limit switches will actuate and cause the READY light to come on.

When the tanker boom nozzle seats in the receptacle, the nozzle actuates the plunger limit switch, completing the circuit of the signal amplifier to the hydraulic toggle latching control valve and to the CONTACT light. As the toggle shafts rotate to the boom latched position, the toggle limit switches are actuated. As a result, power is supplied on the amplifier in the CONTACT condition, causing the ready light to go out. In the CONTACT condition, the signal amplifier supplies voltage to one toggle limit switch and to the CONTACT light.

Disconnect signals to the signal amplifier originate when any one of the following conditions occurs:

- Actuation of the autopilot and ARR disengage button on the pilot's or copilot's control wheel.
- Actuation of a disconnect signal by the tanker boom operator.
- Excessive fuel pressure in the ARR fuel manifold, causing the pressure disconnect switch to actuate.
- A break in contact between the boom nozzle and the receptacle, causing the toggle shafts to

rotate and actuate the toggle limit switches to the unlatched position. This completes a disconnect signal to the signal amplifier.

• When excessive movement of either the receiver or the tanker airplane causes the tanker boom to exceed envelope limits. In this situation, a disconnect signal is initiated by the tanker airplane signal system. Disconnect signal circuits of the receiver and tanker airplanes are interconnected by induction between the induction coils in the boom nozzle and the air refueling receptacle.

When the disconnect signal is received at the signal amplifier, the amplifier is placed in a DISCONNECT condition and the disconnect light will come on. Power is removed, deenergizing the normal toggle control valve, and the contact light goes out. With the toggles released, the disconnect signal, transferred to the tanker through the induction coils, causes the tanker refueling boom to retract and the physical disconnect is completed. Momentarily, pressing the signal amplifier reset button on the air refueling panel removes power from the signal amplifier and places the amplifier in the READY condition. The amber DISCONNECT light will go out and the READY light will glow.

After air refueling is completed and a disconnect has been accomplished, the slipway doors are closed by placing the normal slipway door switch to CLOSE. The DISCONNECT amber light will go out. When the doors close, the door-closed limit switches actuate to energize the slipway door relay, and, as a result, the slipway door CLOSED-AND-LOCKED light comes on. The energized slipway door relay opens the holding circuit for the normal air refueling relay and this deenergizes the "close" solenoid of the slipway door control valve. When the master refuel switch is moved to OFF, power is removed from the air refueling control panel and the slipway door CLOSED AND LOCKED light goes out. The signal system components are protected by circuit breakers on the switched DC circuit breaker panel.

Exercises (642):

1. Name the three systems of the ARR system.
2. What connects the ARR receptacle to the main fuel valve?
3. Even though hydraulic pressure is sent to both the open and closed sides of the slipway doors, why does it open?

4. Why does the toggle actuator have a spring-loaded relief valve?

5. What are the three positions of the signal amplifier?

6. When the slipway doors first start to open, what indication should you get?

7. List the condition that would cause the A/R boom to disconnect.

8. After automatic disconnect, what must be done to place the system back to the READY condition?

4-3. Maintenance of Air Refueling System

The maintenance that you perform on the air refueling system includes the day-to-day tasks that are necessary to keep the equipment in top working order. These tasks include an operational check of the system, removal and installation of system units, repairing components, and servicing the system. Let's discuss the operational check of the system first.

643. Specify why and when operational checks are performed, and why specific steps are required.

Operational Check. Perform an operational check of the boom hydraulic system to insure that all system components are functioning properly. The portions of the check that you perform may include all steps of the check or only certain steps. This depends on the maintenance that has been performed on the system. For example, when the boom on an aircraft has been changed, you perform all steps of the operational check. On the other hand, when you change a component or make an adjustment in the system, you perform only those steps that are necessary to insure the system is functioning properly. Since there are times when all steps of the boom hydraulic system check are performed, let's discuss the complete check.

Figure 4-10 is a check sheet similar to the one included in the TO. Study this figure and see what the check involves. The first part of the check, 1 and 2 in the Action column, is performed with the system unpressurized. The second part of the check, 3 through 31 in the Action column, is performed with the system

ACTION	NORMAL RESULT
Condition: System Unpressurized 1. Move boom hoist lever to LOWER and release. 2. Move boom hoist lever to RAISE without engaging the raise detent and release.	1. Lever returns to "HOLD" unassisted. 2. Lever returns to "HOLD" unassisted. 3. Sighting door opens without binding or sticking. 4. Sighting door closes without binding or sticking and fairs with aircraft fuselage. 5. Boom hoist cable lowers at a rate of 6 to 12 inches per second.
Condition: System Pressurized 3. Position boom operator's sighting door lever to OPEN. 4. Position sighting door lever to CLOSE. 5. Position sighting door lever to OPEN, boom hoist lever to RAISE, and boom latching lever to UNLATCH. Then position the boom hoist lever to LOWER. 6. Position boom hoist lever to RAISE. 7. Lower boom to horizontal position and move hoist lever to hold. 8. Install boom A/R sling assembly, then move boom hoist lever to FREE WHEEL. 9. Pull hoist cable sideways. 10. Pull cable sideways. 11. Reduce pull on cable. 12. Move control stick through full travel in both azimuth and elevation directions. 13. Move control stick to FULL DOWN (0° azimuth) and slowly release. 14. Move control stick to FULL UP (0° azimuth) and slowly release. 15. Move control stick to FULL RIGHT (0° elevation) and slowly release stick. 16. Move control stick to FULL LEFT (0° elevation) and slowly release. 17. Measure force required to move control stick with a spring scale placed at end of stick. 18. Remove boom sling assembly, lower boom to about 10 degrees below horizontal, and position hoist lever to HOLD. CAUTION: Place padded maintenance stand under boom before checking A/R boom emergency hoist system. Stand should be as close to boom as possible to prevent damage if boom drops. 19. Move boom sighting door lever to CLOSE, boom hoist lever to RAISE, and boom emergency hoist manual shutoff valve to EMERGENCY BOOM HOIST. 20. Operate the hydraulic hand pump. 21. Position boom latching lever to LATCHED, boom hoist lever to HOLD, sighting door lever to OPEN, and boom emergency hoist manual shutoff valve to NORMAL.	CAUTION: Do not let the boom fall and strike the ground. 6. Boom hoist cable raises at rate of 1 to 2 inches per second. 7. Boom lowers to and remains in horizontal position. 8. Boom can be moved up and down and to either side. CAUTION: Never position hoist lever to FREE WHEEL with the boom unlatched unless the boom is supported. 9. Cable tension motor exerts a force of about 90 pounds on the cable. 10. Cable extends. 11. Tension motor rewinds cable. 12. Control stick moves easily with one hand through full travel, and ruddervators follow stick movement without noticeable drag. NOTE: Control stick travel with hydraulic power off will be difficult. This is normal and not cause for system rejection. 13. Stick returns to less than 3 inches from the stowed position. 14. Stick returns to less than 3 inches from the stowed position. 15. Stick returns to less than 3 inches from the stowed position. 16. Stick returns to less than 3 inches from the stowed position. 17. Breakaway force from neutral in a side direction is 5.5 pounds. Force required to move the control stick to the upper stop (0° azimuth) is within 6-14 pounds. The force to the lower stop (0° azimuth) is within 28-45 pounds. The force to the right and left stops (at stowed elevation) is within 10-18 pounds. 18. Boom lowers to about 10 degrees below horizontal and stops. 19. Sighting door closes, pressure to boom system stops, hoist control valve is positioned to raise, and boom hoist shutoff valve is closed. 20. Boom is raised fully in about 70 pump strokes. 21. Boom is latched in stowed position, boom hoist control valve positions to hold, sighting door opens and pressure is applied to system, and the manual shutoff valve opens.
Condition: Electrical Power ON 22. Connect external power and turn A/R master switch ON. 23. Move boom telescope lever to maximum EXTEND. 24. Move boom telescope lever to RETRACT. 25. Extend boom about 16 feet with boom telescope lever and allow boom telescope lever to center. Then grasp boom nozzle and pull to extend boom. 26. Push on boom nozzle to retract boom. 27. Check that A/R pump switches are OFF, move fuel dump switch to FUEL DUMP. 28. Return fuel dump switch to NORMAL. 29. Disconnect electrical connector from auto retract control valve. Then hold boom telescope lever in RETRACT and position the fuel dump switch to FUEL DUMP. 30. Hold boom telescope lever in RETRACT and return fuel dump switch to NORMAL. 31. Install the electrical connector to the auto retract control valve. Return controls to normal positions. Position boom sighting door lever to CLOSE, and place A/R master switch to OFF.	22. Electrical power is supplied to the system. 23. Boom extends smoothly and gains speed as lever is advanced to full extend position. Boom travels to full extension in 4.5 to 6.5 seconds. 24. Boom retracts smoothly. 25. Boom does not extend. 26. Boom does not retract. 27. Boom retracts fully and fuel dump actuator depresses boom nozzle poppet valve. 28. Fuel dump actuator extends and poppet valve closes. 29. Fuel dump actuator retracts and opens boom nozzle poppet valve. 30. Fuel dump actuator returns to normal.

Figure 4-10. IFR check sheet.

pressurized. Thus, when performing the second part of the check, apply electrical power, as stated in step 22.

Certain tools and equipment are required to perform the boom hydraulic system operational check. The required tools and equipment are identified as we review figure 4-10. For example, step 8 tells us we need an A/R sling assembly, step 17 indicates we need a spring scale, and the caution following step 18 tells us we need a padded maintenance stand. Also, step 22 indicates we need a ground power unit to supply electrical power. And, of course, we need a hydraulic power unit to supply the hydraulic pressure.

As you study figure 4-10, pay particular attention to the cautions and notes. The cautions are provided to prevent damage to equipment. Notice the caution below step 8 in the Normal Result column. This reminds you that the boom could drop to the ground and be damaged. Be sure to observe all cautions. The notes are provided to give extra information on specific steps or results of the operational check. An example of a note follows step 12 in the Normal Result column. Other information pertaining to the check may appear in the form of warnings. Although a warning isn't shown in figure 4-10, warnings are applicable to some boom hydraulic system checks. For instance, certain types of aircraft radio equipment must be turned off before the check is performed. If radio equipment is operated during the check, a dangerous RF voltage may be induced into the boom. This voltage would endanger personnel performing the check. Be sure to observe all warnings.

Before you perform the operational check on a specific aircraft, check the procedure in the applicable technical order. Remember that procedures differ on some aircraft and you might damage the boom or injure personnel if you follow incorrect procedures.

Exercises (643):

1. Referring to figure 4-10, item 18, why does it require that a padded maintenance stand be used to support the boom?
2. Explain why the complete operational check of the boom system is not necessary when the hydraulic accumulator has been removed and replaced.
3. Why is it necessary to turn off certain types of aircraft radio equipment before an operational check is made?
4. Refer to step 17 of figure 4-10. Why is a spring scale necessary?

644. Stipulate some of the items checked for during an inspection and then specify general information pertaining to the removal and installation of the A/R system components.

Air Refueling System Inspection. The A/R system is inspected IAW the -6 TO or workcards. The A/R system consists of hydraulic, fuel, electrical, and mechanical systems; each should be inspected. To give you some idea on the items that should be checked, we have separated the A/R system into each system. Check the hydraulic system for leaking, chaffed, or otherwise damaged lines or hoses. Inspect the units themselves for leakage and security of mounting. Some items like the accumulator should be checked to insure proper servicing. Check also the items in the fuel system for leakage, security of mounting, and in the case of the nozzle, for damage. Check the fuel surge boot for servicing. Check the electrical system for loose wires and cuts in the insulation; the signal coil on the nozzle for corrosion; the mechanical components, cables, pulleys and levers for damage, binding, and in proper operation.

This of course is just a sample of items that should be checked during the inspection of the boom system. Any items that are found defective should be written up for corrective action. In many cases the items will have to be removed and replaced.

Removal and Installation of Components. Removal and installation, or replacement, of units in the boom system may take a major part of your time until you become proficient in performing the task. Procedures for removing and installing specific system units are included in technical orders. However, some general information applies when removing and installing any unit.

First, you know that safety is very important when any unit in the system is removed or installed. Safety practices include special precautions to keep you from damaging equipment or injuring personnel. Some of these precautions are:

- a. Depressurize the system before removing a unit. If the air refueling hydraulic system is not depressurized, the boom may be accidentally extended, and injury to personnel and equipment could result.
- b. Turn off any radio equipment that might induce an RF voltage in the boom. It is possible for RF voltages to ignite combustible vapors.
- c. Observe the NO SMOKING signs. Doing so reduces the danger of igniting fuel vapors that might be present.
- d. Plug or cap open ends of tubing or lines. Doing so keeps foreign matter out of the system.
- e. Place a stand under the boom where the ruddervators connect. If the stand is positioned in any other area, the boom fairing will be crushed. (This precaution is required when the boom is lowered to remove a unit.)

Second, you know that tools and equipment are required for removing and installing a unit. But what tools and equipment are required? Usually you need only the common handtools from your toolbox. However, when additional special tools and equipment are needed, you can identify them as you check the technical order procedure for removing and installing the unit.

Exercises (644):

1. List two items hydraulic hoses would be inspected for.
2. Why is it necessary to depressurize the system before removing any of the units?
3. What should a cable be checked for?
4. After removing a hydraulic component, caps and/or plugs should be put over all the open parts and tubing. Why is this necessary?

645. Identify the steps to use when troubleshooting an A/R system and then identify the probable causes for given symptoms and conditions.

Troubleshooting. The ability to find the cause of a trouble is one of the differences between an average repairman and a top repairman. If you expect to get to the "top of the heap," you must be able to troubleshoot. You should adopt some orderly system of trouble analysis. The problem-solving method is one of many systems. It consists of the following steps: (1) become aware of the problem; (2) investigate and research; (3) eliminate possibilities; (4) isolate the trouble; (5) prove your conclusions; and, finally, (6) correct the trouble.

Become fully aware of the trouble. That is, get a clear idea of the problem. Read the writeup, if there is one, and talk to the person who discovered the trouble. Perform as complete an operational check as the circumstances permit. The operational check can be the basis for troubleshooting. Notice all the symptoms of unsatisfactory system operation. Determine the difference between normal operation and unsatisfactory operation. The analysis of the trouble during the operational check can be fairly simple if you know the following:

- Why you perform the check.
- Purpose of each part of the check.

- What units you check.
- What is taking place within the system during the check.

Investigate and research. The next step is to enforce your knowledge of system details. The -2 technical manual for your aircraft provides information on the purpose and construction of each unit in the system. The TO also contains a schematic or diagram that show how the lines and units of the system are connected. Troubleshooting charts are usually included in the -2 TO.

Troubleshooting charts are similar in design. However, they vary in the way in which they cover the various systems. They state the trouble, probable cause, isolation procedures, and corrective action. When such a chart is available, use it. Normally, the chart has the common troubles listed in the left-hand column. Look through the troubles until you find one that matches the observed trouble indications. See figure 4-11.

Eliminate possibilities. When a troubleshooting chart is available, your elimination of the probable cause of a problem is a simple matter. However, in some cases a chart may not be included in the aircraft manual. Under these conditions, prepare a list of all units in the system that could produce the observed symptoms. After listing all probable causes, examine each unit to determine whether or not it could really cause the trouble. Eliminate those components that could [not] produce all the indicated symptoms.

Isolate trouble. After all of the probable causes have been established, whether through a troubleshooting chart or your own list, analyze the remaining causes from the standpoint of probability. To save time, examine the probable causes that can be checked easily before you try those that require involved check procedures.

Prove your conclusions. Probably the greatest temptation for any troubleshooter is to jump to conclusions. Evidence of this is seen in the number of units removed as "unserviceable" and later shown by bench check to be serviceable. Each of these replacement errors represents a great deal of wasted work and expense. So before reaching a conclusion, use enough checks to prove that you are right.

Correct trouble. To eliminate the trouble, you should correct the fault by repair, replacement, or adjustment of the responsible unit or units. Then operate the system to be sure that you have restored normal system operation.

Exercises (645):

1. Which of the following systems would you do first?
 - a. Isolate the trouble.
 - b. Eliminate possibilities.
 - c. Correct the trouble.

TROUBLE	PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
Boom extends or retracts sluggishly	No preload on accumulator	Check accumulator for specified pressure	Recharge accumulator
	Defective telescope control valve	Open sighting door and check response of boom by manually moving valve arm	Replace defective control valve 
Ruddevator power unit leaking at exposed piston rod seal, at opening near head end mounting bolt, at exposed slide seal or at drain hole in slide plug	Defective piston rod seal or slide seal	Wipe area dry. Pressurize right hydraulic system. Position door control lever to OPEN. Move ruddevator control stick through five full cycles in either azimuth or elevation direction. Depressurize system and check for leakage	If leakage at any one point exceeds one drop, replace power unit 
 After replacement of system components or associated tubing, bleed the hydraulic system per applicable component installation paragraph.			

42-2010

Figure 4-11. Troubleshooting.

2. What should you do to prove you have located and corrected the trouble?
3. The boom will extend and retract, but it does it very sluggishly. What items could be considered as probable causes?

Study the troubleshooting chart in figure 4-11. Using your understanding of hydraulics, your knowledge of the A R hydraulic system, and the troubleshooting chart, solve the following situations.

4. The ruddevator power cylinder is leaking at the piston rod seal. What is the maximum leakage allowed?

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

- 600 - 1. A vent line filter.
- 600 - 2. Because of the vibration of the pump. If a metal line were installed it would eventually fail.
- 600 - 3. Suction boost pump.
- 600 - 4. For cooler operation.
- 600 - 5. Low pressure.
- 600 - 6. By the indicator button on the filter assembly.
- 600 - 7. Check valve.
- 600 - 8. Fire control tee handle, which will close off the supply of fluids to the pumps.
- 600 - 9. To cool the fluid in the system.
- 600 - 10. a. Fire tee handle.
b. Engine pump switch.
- 601 - 1. The reservoir is pressurized by system operating pressure.
- 601 - 2. To make it easier to remove and install the pump.
- 601 - 3. For pump vibration.
- 601 - 4. It reduces the natural ripple produced by most piston-type pumps.
- 601 - 5. Low system pressure.
- 601 - 6. Case drain of the pump.
- 601 - 7. By thin tubing between the fuel and hydraulic system.
- 601 - 8. To the system manifold.
- 601 - 9. 1. Filter assembly.
2. Quick disconnect.
3. Check valve.
4. Relief valve.
- 601 - 10. Fuse.
- 602 - 1. The air compressor would not be lubricated properly and may be damaged.
- 602 - 2. Auxiliary air regulator.
- 602 - 3. It will come out the drain on the access door.
- 602 - 4. The thermostat heating blanket.
- 602 - 5. Air servicing valve filter and direct reading pressure gage.
- 602 - 6. A filter in the dump valve port.
- 602 - 7. The hydraulic flow regulator between the hydraulic control valve and air compressor.
- 602 - 8. 1. The hydraulic control valve.
2. The dump valve solenoid.
- 603 - 1. Servicing markings on the aircraft.
- 603 - 2. Besides using the TO, the pressure should be depleted.
- 603 - 3. Check the air charge in the accumulator.
- 603 - 4. The pressure should be decreased. The reason why is that when the temperature rises, the gas will expand.
- 603 - 5. The technical order and data plate.
- 603 - 6. 1. The type of fluid that should be used.
2. The position of the system.
3. The pressure that must exist before servicing.
- 603 - 7. The reservoir may burst because of the large volume of fluid being pumped into the reservoir.
- 603 - 8. a. The subsystems in the wrong position.
b. The accumulator charged with fluid pressure.

- 603 - 9. By looking at the filter indicator button.
- 603 - 10. Leakage and security of mounting.

- 604 - 1. 1. a.
2. c.
3. b.
4. a, b.
 - 604 - 2. a. Check it against the accumulator gage or install a pressure test gage.
b. Before running the engine, you should have the proper TO. By looking in the TO, you could have answered the pilot's question.
c. You should have insured that the reservoir was serviced properly before running the engines.
 - 605 - 1. a. Pump pressure.
b. Supply.
c. Shaft seal drain.
d. Case drain.
 - 605 - 2. To remove the air in the pump. If the air is not removed, it could damage the pump during operation.
 - 605 - 3. To make it easier to install and to prevent the splines from wearing.
 - 605 - 4. The hydraulic test cannot pressurize the aircraft pump. The engines will have to be run.
 - 605 - 5. Deplete the pressure in the system. Next remove the filter bowl and remove the old element. Replace all O-ring seals. Install the new element and then the filter bowl.
 - 605 - 6. To eliminate the air in the system.
 - 605 - 7. In the TO or in some cases printed on or near the filter bowl.
 - 605 - 8. That the system is contaminated.
 - 605 - 9. The air will not pass through the cartridge.
 - 605 - 10. The cartridge is installed so that the arrow and the word "flow" is pointing in the direction of the outlet port.
 - 606 - 1. By taking a sample of the fluid and performing a contamination test. Another way is to look at the color of the fluid.
 - 606 - 2. Because some units cannot be drained properly by disconnecting the lines to it.
 - 606 - 3. Because many of the valves or units would prevent the fluid being used for flushing to pass freely through them.
 - 606 - 4. Purging is used primarily with pneumatic systems. It is defined as the cleansing of a system.
 - 606 - 5. Condensation.
- ### CHAPTER 2
- 607 - 1. Tricycle and quadricycle.
 - 607 - 2. So that the landing shock is distributed as widely as possible throughout the main body of the structure.
 - 607 - 3. a. Forward visibility for takeoff and taxiing was improved.
b. Ground looping was eliminated.

- c. Hard application of brakes without fear of noseover.
- 607 - 4. Multiple-axle (bogie) truck-type main landing gear.
- 607 - 5. Weight displacement and tire size.
- 607 - 6. Lateral stability during heavy gross weight landings.
- 607 - 7. Four main gears mounted in the fuselage in the form of a rectangle and two outrigger or tip projection gears. Because it is used only on the B-52 aircraft.
- 607 - 8. Allows for thinner wing design and therefore greater speed. Landing forces are more evenly distributed over the whole aircraft. Makes use of shorter, yet larger, main landing gear assemblies.
- 608 - 1. To prevent accidental collapsing of the landing gear while the aircraft is on the ground.
- 608 - 2. Pulled away from the control handle.
- 608 - 3. Electrical circuit is open.
- 608 - 4. Pull the lock release finger latch down.
- 609 - 1. A picture of a barber pole.
- 609 - 2. When the pilot forgets to lower the gear during landing procedures.
- 609 - 3. By pushing the warning horn silence button.
- 609 - 4. Whenever the landing gear is between the DOWN or UP and LOCKED position.
- 609 - 5. Left main gear indicator will show a wheel, right main gear indicator will show the word "UP," and nose gear indicator will show a barber pole.
- 610 - 1. No. Electrical power goes directly to the control valve and ground, and the sequence switches are not used for gear extension.
- 610 - 2. A hydraulic motor that turns a gear box.
- 610 - 3. The gear box brake.
- 610 - 4. Manually by a hand crank.
- 610 - 5. Deplete all hydraulic pressure before actuating the emergency system.
- 610 - 6. The nose gear is locked in the UP position by an uplock cylinder and in the DOWN position by an internal lock built into the actuating cylinder.
- 610 - 7. The NLG emergency extension valve is placed in the EMERGENCY position.
- 610 - 8. A 2-way flow regulator.
- 610 - 9. A shuttle valve.
- 610 - 10. A shuttle valve.
- 611 - 1. Main gear scissors switch, nose gear limit switch, main gear inboard door close limit switch.
- 611 - 2. By a sequence valve that is actuated by the rotation of the uplock hook.
- 611 - 3. By integral down locks built into the actuators.
- 611 - 4. Deenergized.
- 611 - 5. It is dumped overboard. High-pressure air from the emergency air bottles actuate a pressure operated dump valve.
- 611 - 6. Gear down sides of the drag brace actuator and the uplock actuator.
- 611 - 7. The uplock mechanism.
- 611 - 8. It actuates a sequence valve that allows hydraulic fluid to flow to the uplock actuator.
- 611 - 9. As the down lock limit switch or each actuator breaks contact.
- 611 - 10. A pin on the strut fork.
- 611 - 11. A restrictor.
- 611 - 12. By mechanical linkage.
- 612 - 1. Used to halt the forward motion of the aircraft if wheel brakes, speed brakes, and drag chute fail to operate.
- 612 - 2. It controls the flow of hydraulic fluid going to the vertical damper cylinder.
- 612 - 3. By a spring-loaded uplatch and in the DOWN position.
- 612 - 4. Air-oil pressure in the top of the vertical damper cylinder and the weight of the arresting hook.
- 612 - 5. Surge damper.
- 612 - 6. By a control lever that releases tension from the arresting hook control cable which releases the spring-loaded uplatch mechanism.
- 612 - 7. A 2-way restrictor.
- 612 - 8. 1.1 seconds from the time the arresting hook contacts the hook up limit switch.
- 613 - 1. To the right.
- 613 - 2. Fluid in the steering cylinders would have to transfer from one cylinder to the other.
- 613 - 3. A followup action.
- 613 - 4. Cylinder barrels are stationary, piston rods are movable.
- 613 - 5. Lower torque link.
- 613 - 6. The rocker arm.
- 614 - 1. Command potentiometer and followup potentiometer.
- 614 - 2. The solenoid in the nose gear steering valve deenergizes and shuts off hydraulic fluid to the steering system.
- 614 - 3. Prevents cavitation of the vane motor and dampen shimmy when the steering system is not energized.
- 614 - 4. The steering (command) potentiometer.
- 614 - 5. The servo valve holds the wheels at the desired degree of turn.
- 614 - 6. Nose gear down limit switch, right main gear scissors switch, and the landing gear control switch.
- 614 - 7. Nose gear steering switch.
- 614 - 8. Bypass valve.
- 615 - 1. Utility hydraulic system.
- 615 - 2. Slow-release fail-safe relay.
- 615 - 3. The emergency selector valve is energized and the normal brake selector valve is deenergized.
- 615 - 4. The brake control valve.
- 615 - 5. Both brake selector valves will be positioned to allow operation from either the utility or auxiliary hydraulic system.
- 615 - 6. Nonrotation and/or a rapid change in wheel speed.
- 615 - 7. By the locked-wheel detection relays.
- 615 - 8. The touchdown protection circuit.
- 615 - 9. Brake pressure releasing valve.
- 615 - 10. If you don't, you will bleed away pressure faster than the handpump can be operated.
- 616 - 1. Antispin system.
- 616 - 2. Memory locked wheel protection circuit.
- 616 - 3. By depressing the rudder brake pedals in either the forward or aft cockpit.
- 616 - 4. The size of the opening of the pressure port in the control unit.
- 616 - 5. By pulling aft on the emergency brake handles and depressing the rudder brake pedals.
- 616 - 6. Negative.
- 616 - 7. Because during emergency operation hydraulic fluid does not flow through the antiskid valve.
- 616 - 8. Gear up line.
- 616 - 9. By the movement of the exciter ring through the magnetic field of the sensor.
- 616 - 10. Enough for 11 to 13 brake applications.
- 616 - 11. When the aircraft speed is less than 15 knots.
- 617 - 1. Remove and replace the line and look for the cause of the chaffing.
- 617 - 2. Leakage, security of mounting, proper adjustment.
- 617 - 3. Cuts, broken wires.
- 617 - 4. Wear, overheating, corrosion, leakage.
- 617 - 5. Adjusting, binding, security of mounting, leakage.
- 617 - 6. Being broken or cracked.
- 618 - 1. Step 1, assemble all tools.
- 618 - 2. Step 5, cap or plug the lines.
- 618 - 3. Step 3, depressurize hydraulic system.
- 618 - 4. Step 5, tag the lines to indicate to what ports they should be installed.
- 618 - 5. New O-ring seals were not installed.

- 618 - 6. Operational check was not made.
- 619 - 1. Periodic inspection, when maintenance is performed, that might affect gear linkage or adjustment, after a hard landing, or the pilot reports a malfunction.
- 619 - 2. Hydraulic test stand and an electrical power unit.
- 619 - 3. It depends on the specific aircraft. Check the applicable aircraft technical order.
- 619 - 4. High enough to allow the landing gear to safely clear the ground during all operational actions.
- 619 - 5. Bleed the hydraulic system of air.
- 619 - 6. Barber pole.
- 619 - 7. Until the system is clear of air.
- 619 - 8. After the gears have been cycled a minimum of three times.
- 619 - 9. To catch any hydraulic fluid that might have poured out during emergency extension.
- 619 - 10. Prior to applying hydraulic and electrical power.
- 620 - 1. Instruction plate on the strut near the filler inlet and air valve assembly and in the applicable aircraft TO.
- 620 - 2. Shock strut must be deflated and in the full compressed position.
- 620 - 3. Remove all stands, jacks, and obstructions from under the aircraft. Make sure all personnel are clear of the aircraft.
- 620 - 4. Approximately 450 psi.
- 620 - 5. To eliminate any binding that might take place between the inner and outer cylinders.
- 620 - 6. When you cannot get another drop in it without overflowing.
- 620 - 7. They could cause damage to the aircraft when it is lowered.
- 620 - 8. It would decrease the shock absorbing capabilities of the strut and could cause the strut to bottom out.
- 621 - 1. Pressure is trapped in the system for shimmy damper operation and will squirt out when the hydraulic lines are loosened.
- 621 - 2. The system could be contaminated.
- 621 - 3. Assemble all the tools and equipment needed to remove it.
- 622 - 1. Neutral 0°.
- 622 - 2. The nose gear can be positioned without placing too much of a bind on it.
- 622 - 3. Check the plate that is usually mounted on the nose gear collar.
- 622 - 4. To allow the centering cams in the nose strut to position the nose gear in the NEUTRAL position.
- 623 - 1. Air is in the system.
- 623 - 2. He did not keep enough fluid in the brake reservoir.
- 623 - 3. Some fluid was not drained from the brake system reservoir before the bleeding was started.
- 623 - 4. To prevent system contamination.
- 623 - 5. To prevent fluid and air from being drawn back into the system from the receptacle.
- 623 - 6. To the bleeder port on the brake unit.
- 623 - 7. Until no air bubbles appear and the spongy pedal action is eliminated.
- 624 - 1. Step 1. e.
Step 2. c.
Step 3. a.
Step 4. d or g.
Step 5. f.
Step 6. b.
Step 7. d or g.
Step 8. i.
Step 9. h.
Step 10. j.
Step 11. k.
- 625 - 1. You should check for any visible damage to the unit which could cause the malfunction or discrepancy.
- 625 - 2. So there will be no foreign matter left to contaminate the system when the unit is reassembled and insure a more accurate inspection.
- 625 - 3. They should be replaced together or put back in the same place they were removed from.
- 625 - 4. To make sure it operates properly.
- 625 - 5. To locate those parts that are bad or doubtful.
- 625 - 6. The unit supply document number.
- 625 - 7. When all the parts needed for the repair were not available.
- 625 - 8. Put the unit with all its parts in an AWP storage bin.

CHAPTER 3

- 626 - 1. Camber is defined as the curve of the surface of an airfoil from the leading edge to the trailing edge.
- 626 - 2. Thrust.
- 626 - 3. Weight (gravitational pull).
- 626 - 4. Lift.
- 626 - 5. Drag.
- 626 - 7. Longitudinal.
- 626 - 8. When the aircraft is in straight and level unaccelerated flight.
- 626 - 9. Thrust and drag.
- 626 - 10. By the pressure differential acting on the top and bottom of the wing.
- 627 - 1. Lateral axis.
- 627 - 2. Rudder.
- 627 - 3. Ailerons.
- 627 - 4. Right aileron raised, left aileron down.
- 627 - 5. Rudder.
- 627 - 6. On the trailing edge of controls such as the elevator, rudder, and ailerons.
- 627 - 7. Spoilers.
- 627 - 8. Spoiler.
- 627 - 9. Used to increase drag to slow the aircraft and reduce landing distance.
- 627 - 10. Increase lift, increase drag.
- 627 - 11. Under the trailing edge of the wings.
- 627 - 12. Elevators.
- 627 - 13. Trim tab on the elevators.
- 627 - 14. Movable horizontal stabilizer.
- 628 - 1. Artificial feel system.
- 628 - 2. No.
- 628 - 3. Electrical trim system.
- 628 - 4. Stability augmentation (stab aug) and autopilot (A/P).
- 628 - 5. Used to make the aircraft a stable platform from which weapons can be launched.
- 628 - 6. Used for pilot relief (to fly the aircraft along a predetermined course selected by the pilot).
- 629 - 1. e.
- 629 - 2. g.
- 629 - 3. i.
- 629 - 4. b.
- 629 - 5. j.
- 629 - 6. f.
- 629 - 7. d.
- 629 - 8. h.
- 629 - 9. a.
- 629 - 10. c.
- 630 - 1. Hydraulic.
- 630 - 2. To control the flow of hydraulic pressure into the system.
- 630 - 3. Through a servomotor.
- 630 - 4. To prevent damage to the rudder supporting structure.
- 630 - 5. By placing the rudder switches to ON.
- 630 - 6. By a switch on the wing flaps.
- 630 - 7. Through mechanical force.
- 630 - 8. The rudder boost system shutoff valves were closed.
- 630 - 9. Energized.

- 631 - 1. Mechanically and hydraulically.
 631 - 2. If one side became jammed, the override spring would deflect under force and allow operation of the other lateral control surfaces.
 631 - 3. Yes.
 631 - 4. Yes.
 631 - 5. Yes. The feel selector valve is energized, letting hydraulic fluid actuate feel cylinder piston.
 631 - 6. Aileron control valves and spoiler servo valves.
 631 - 7. Stability augmentation on AFCS.
 631 - 8. Double action spring cartridges connected in tandem with screw jack actuators.
 631 - 9. Cause rudder displacement proportional to aileron displacement to provide coordinated turns at low airspeeds.
 631 - 10. A dynamic bellows acting through a bob weight and variable bell crank on the trim actuator.
 631 - 11. Meters hydraulic fluid to the power cylinder.
 631 - 12. Allows the feel and trims portion to be bypassed in the event of noseup trim malfunction.
- 632 - 1. An unsynchronized condition.
 632 - 2. Manually.
 632 - 3. Hydraulic disc flap brake.
 632 - 4. Solenoid-operated wing flap selector valve.
 632 - 5. To the flap motor.
- 633 - 1. A selector valve, a flow divider, and the trailing edge flap actuating cylinder.
 633 - 2. It is dumped overboard.
 633 - 3. Shuttle valves.
 633 - 4. DOWN.
 633 - 5. A flow divider and into the down side of the TE flap actuating cylinder.
 633 - 6. A selector valve, flow divider, and the LE and TE flap actuating cylinders.
- 634 - 1. Checking to see that the control surfaces go to the right position when the control device in the cockpit is moved.
 634 - 2. Hydraulic test stand and generator set.
 634 - 3. Make sure it has been cleared.
 634 - 4. These are points where breaks in the cables often take place.
 634 - 5. Replace the pulley.
 634 - 6. To measure the travel of the control surface.
 634 - 7. To ascertain the maximum allowable component leakage rate.
 634 - 8. No. Most templates are made for particular aircraft.
- 635 - 1. The applicable aircraft organizational maintenance manual.
 635 - 2. Check for proper operation.
 635 - 3. To prevent cross-connection during installation.
 635 - 4. Shop capabilities and -6 TO limitations.
 635 - 5. Read each step of the technical order individually.
 635 - 6. Cap the lines and hoses.
- 638 - 3. He should increase his altitude and decrease his airspeed.
 638 - 4. Azimuth position is not controlled by the pilot direct lights.
- 639 - 1. By gravity flow.
 639 - 2. In the forward and aft body tanks.
 639 - 3. By the manual override handle on the line valve.
 639 - 4. The hydraulic shutoff valve must be energized. When this happens hydraulic pressure is available to operate the hydraulic motors.
 639 - 5. It senses the fuel flow through the boom.
 639 - 6. The fuel bypass valve.
 639 - 7. Fuel bypass control valve.
- 640 - 1. Boom hoist, tension motors, and ruddervators.
 640 - 2. a. Boom operators sighting door.
 b. Boom hoist.
 c. Boom telescope.
 d. Fuel bypass.
 e. Fuel dump.
 f. Ruddervators.
 640 - 3. The fuel dump actuator pushes the check valve in the nozzle which allows the fuel to be dumped.
 640 - 4. The bypass valve will dump the fuel pressure into the aft body tank when the boom is placed to the retract position. To all the hydraulic subsystems.
 640 - 5. The ruddervators are used to fly the boom.
 640 - 6. It positions the control valve on the ruddervator power unit.
 640 - 7. The tension motor drives a drum which takes up the slack in the boom hoist cable.
 640 - 8. In the LOWER position.
- 641 - 1. By the signal coil on the boom nozzle.
 641 - 2. The ready light.
 641 - 3. Power will be applied to pin F of the signal amplifier, which will automatically cause a system disconnect.
 641 - 4. 7 inches.
 641 - 5. 1. When the receiver aircraft moves out of its envelope.
 2. By boom operator's disconnect switch.
 3. A signal through the signal coil from the receiver aircraft.
- 642 - 1. a. Fuel system.
 b. Hydraulic system.
 c. Electrical system.
 642 - 2. 4-inch fuel tube.
 642 - 3. Because of the larger area on the open side of the piston. The relief valve will bypass fluid down the retract side if pressure becomes excessive on the pullaway of the air refueling nozzle from the receptacle.
 642 - 4. READY, CONTACT (MADE), and DISCONNECT.
 642 - 5. The door CLOSED AND LOCKED light will go out.
 642 - 6. a. Actuation of the autopilot ARR disengage button.
 b. Actuation of a disconnect signal by the tanker boom operator.
 c. Excessive fuel pressure.
 d. A break in contact between the tanker and receiver aircraft.
 e. When the receiver aircraft exceeds the envelope limits. The reset button must be placed to the RESET position. This momentarily drops power to the amplifier.
 642 - 8.
- 643 - 1. So the stand and boom are not damaged.
 643 - 2. The accumulator would only require a pressure check. You should only perform the necessary steps to insure that the component is operating properly.
 643 - 3. Because of the dangerous voltage that may be induced into the boom.
 643 - 4. To insure the proper amount of force in order to move the ruddervator control stick.
- 644 - 1. Leaking or chafed hoses.

CHAPTER 4

- 636 - 1. b.
 636 - 2. c.
 636 - 3. a.
 636 - 4. c.
 636 - 5. b and c.
- 637 - 1. Ring spring assembly.
 637 - 2. Surge boot.
 637 - 3. They center and support the inner structural tube.
 637 - 4. Motor-driven sprocket and chain assembly.
 637 - 5. Gland seals.
- 638 - 1. The pilot director light will indicate the position to the receiver pilot.
 638 - 2. By the markings on the boom.

- 644 - 2. If the hydraulic pressure is not depleted, the boom may be accidentally extended, and injury to personnel and equipment could result.
- 644 - 3. For damage, binding, and proper operation.
- 644 - 4. To prevent dirt or contamination from entering the system.

- 645 - 1. Eliminate the possibilities.
- 645 - 2. Perform an operational check of the system.
- 645 - 3. You should check the accumulator air charge or telescope control valve.
- 645 - 4. One drop.

42354 04 S01 7805

SUPPLEMENTARY MATERIAL

CDC 42354

**AIRCRAFT PNEUDRAULIC SYSTEMS
MECHANIC**

(AFSC 42354)

Volume 4

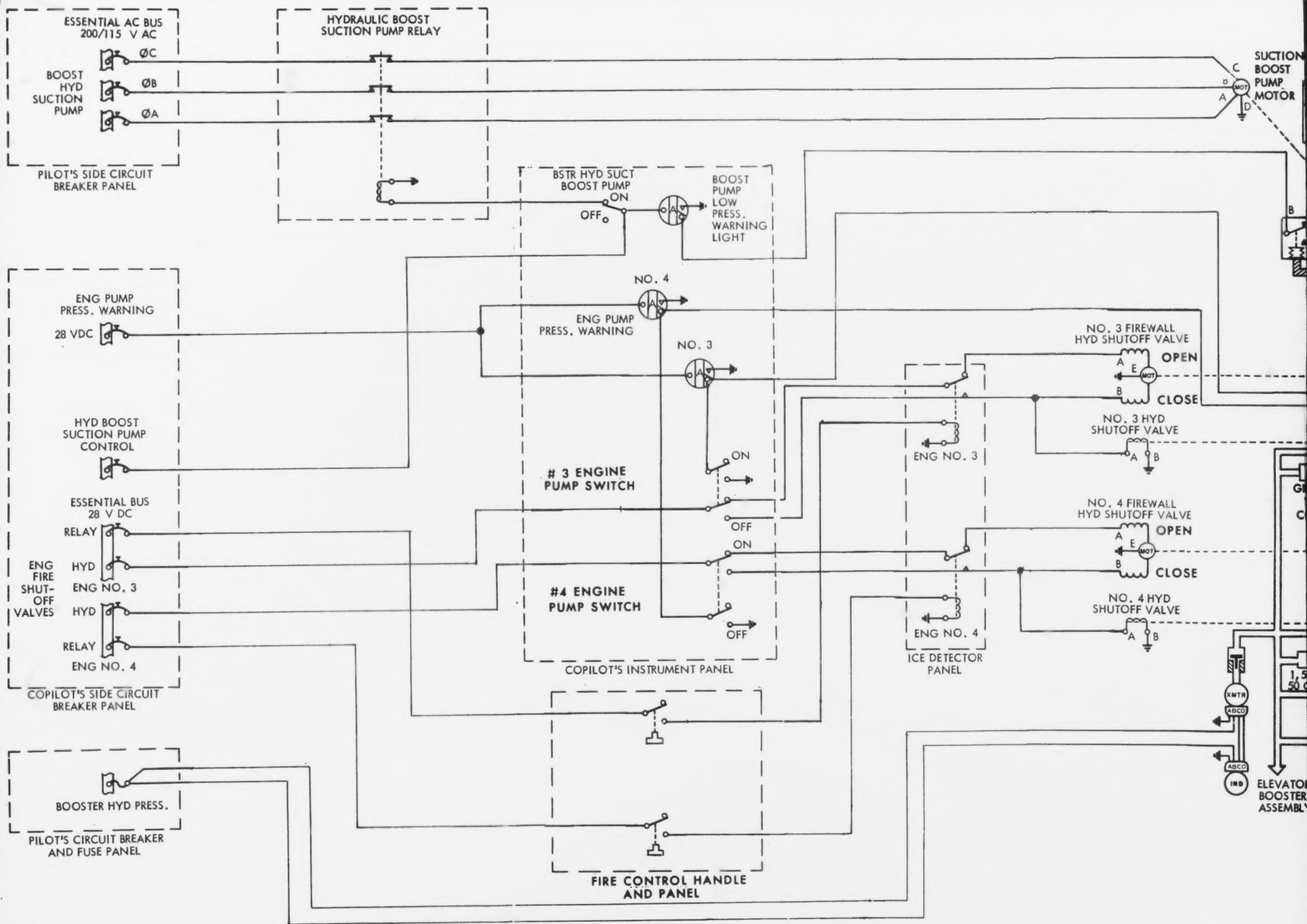
Foldouts 1 through 11

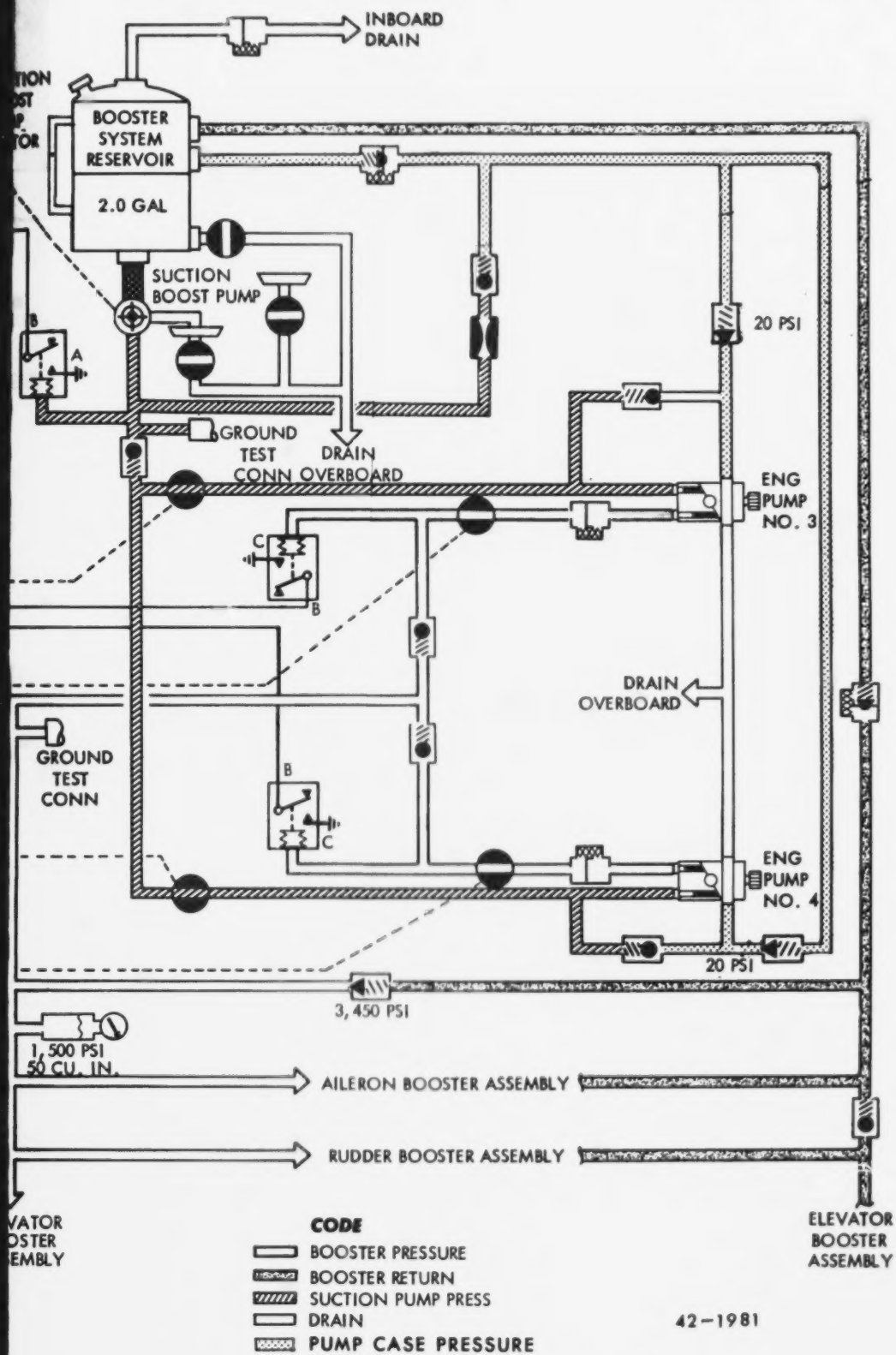
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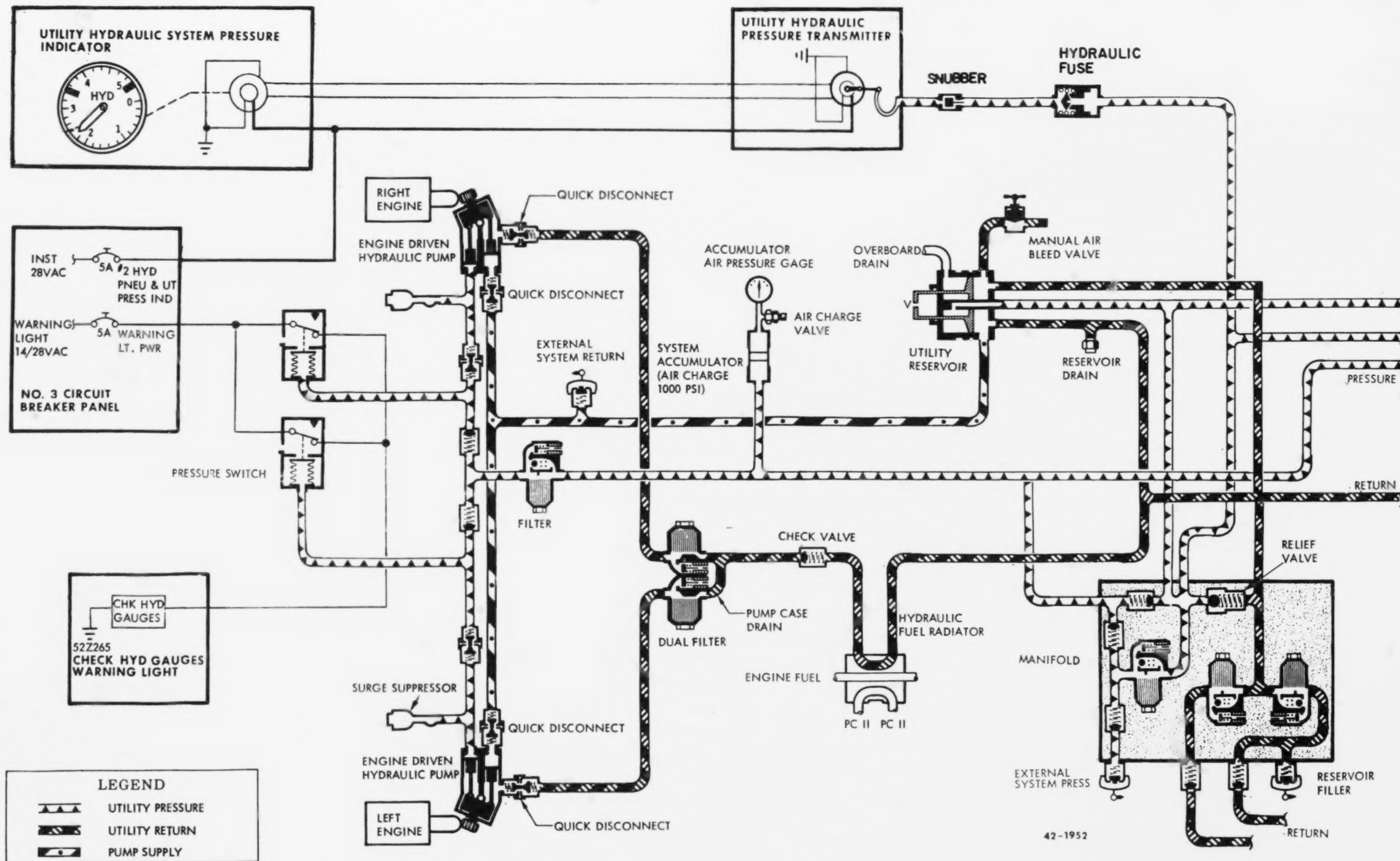
Air University



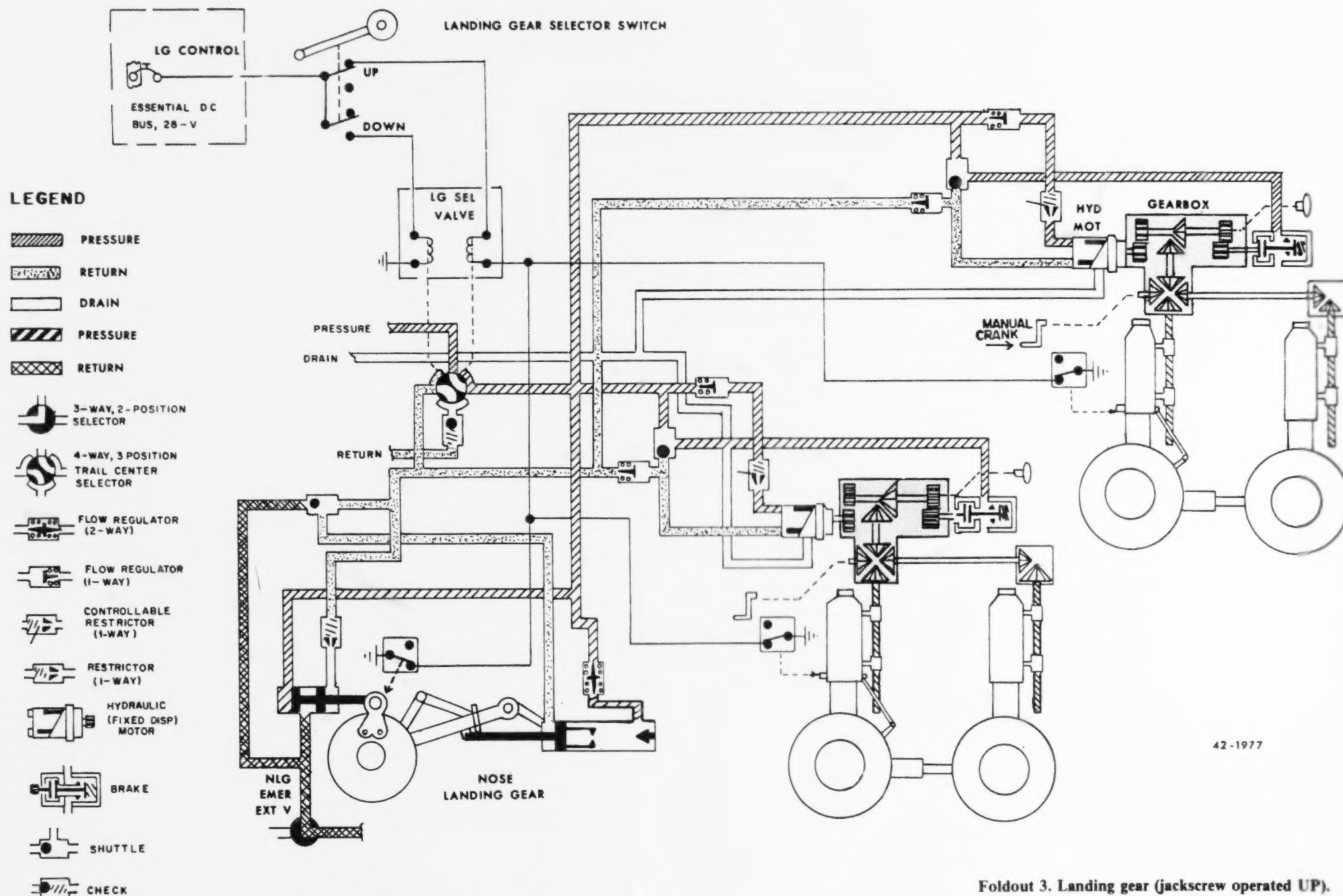


42-1981

Foldout 1. Hydraulic power supply system (large aircraft).

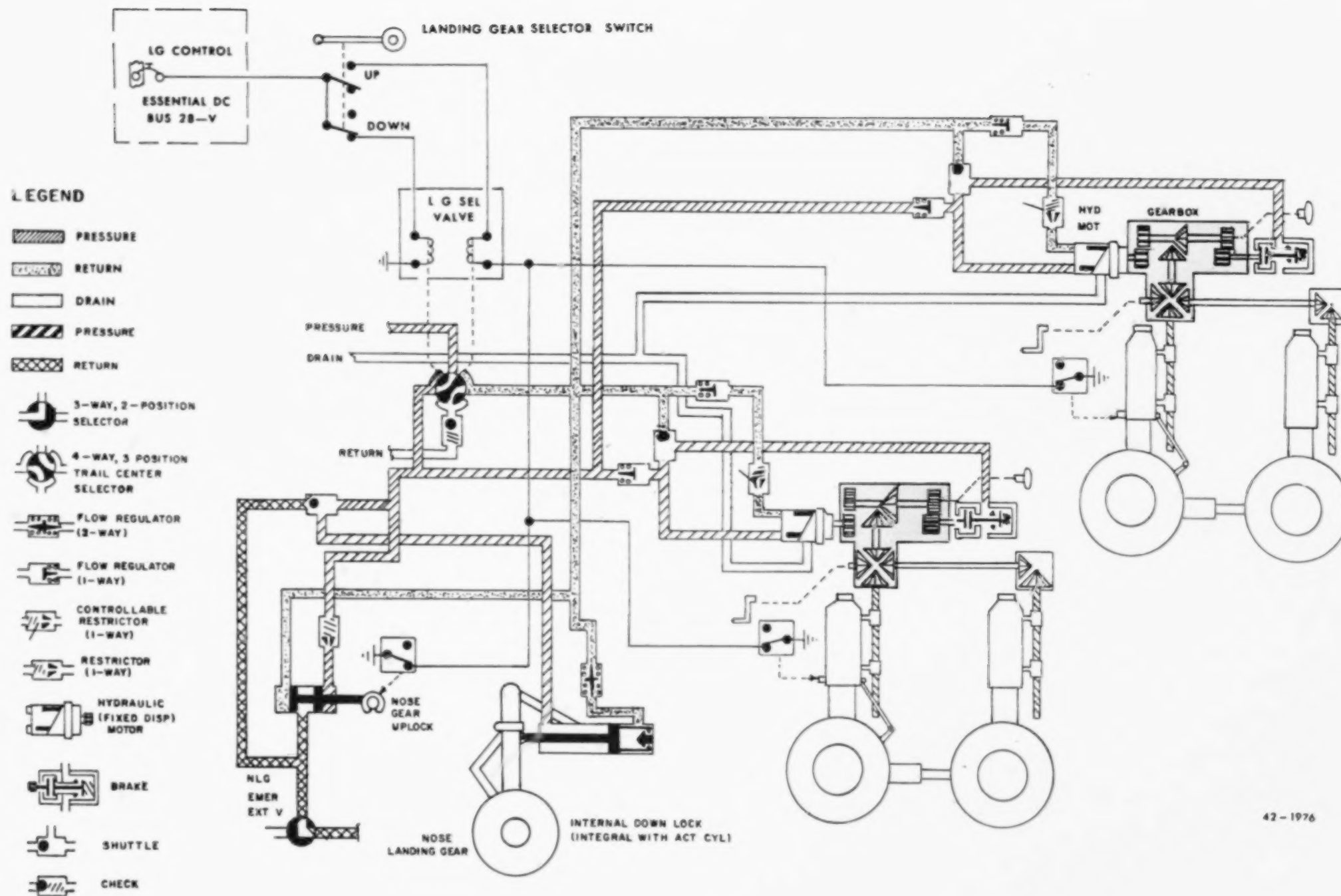


Foldout 2. Hydraulic power supply system (small aircraft).



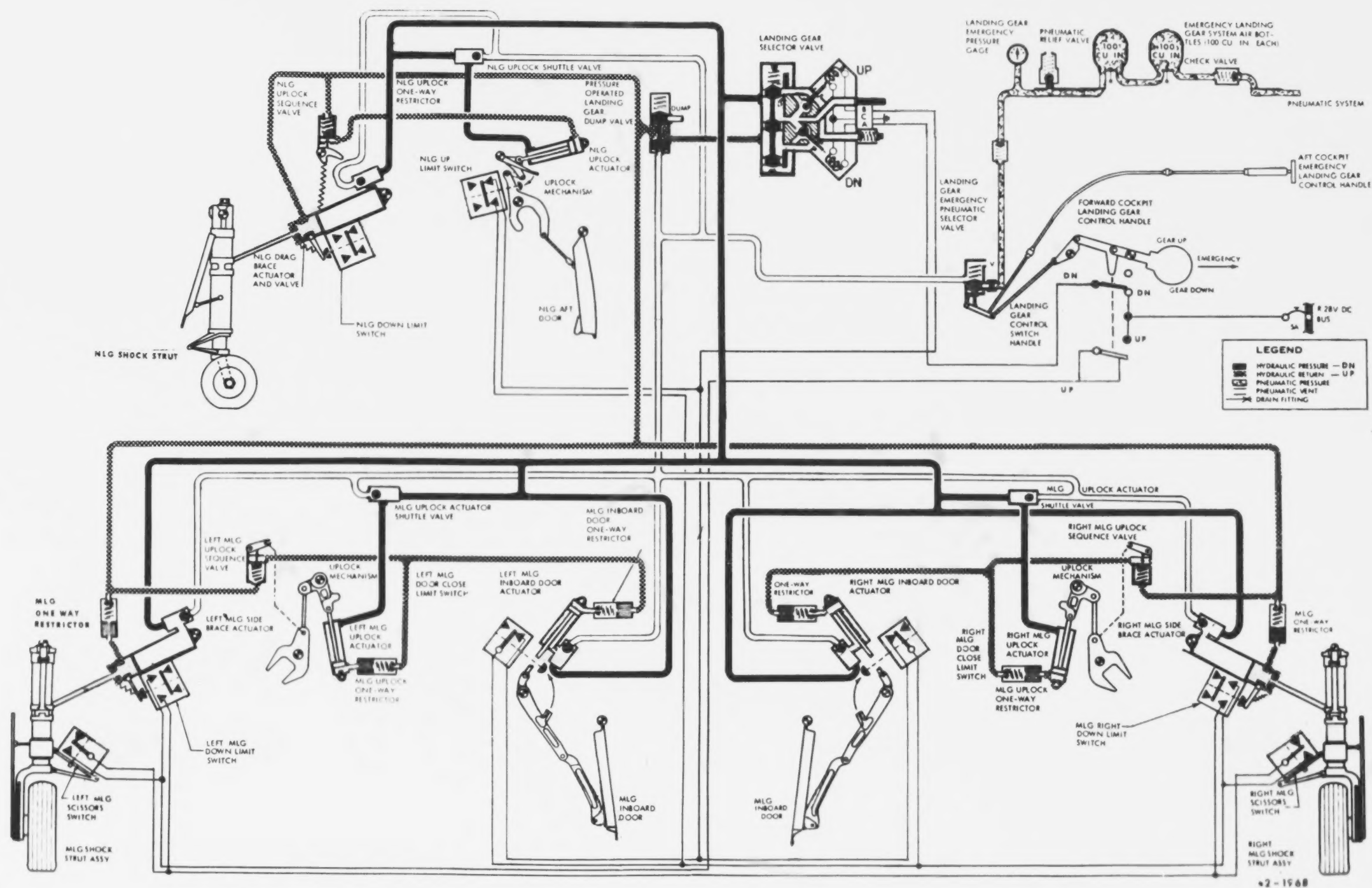
42-1977

Foldout 3. Landing gear (jackscrew operated UP).

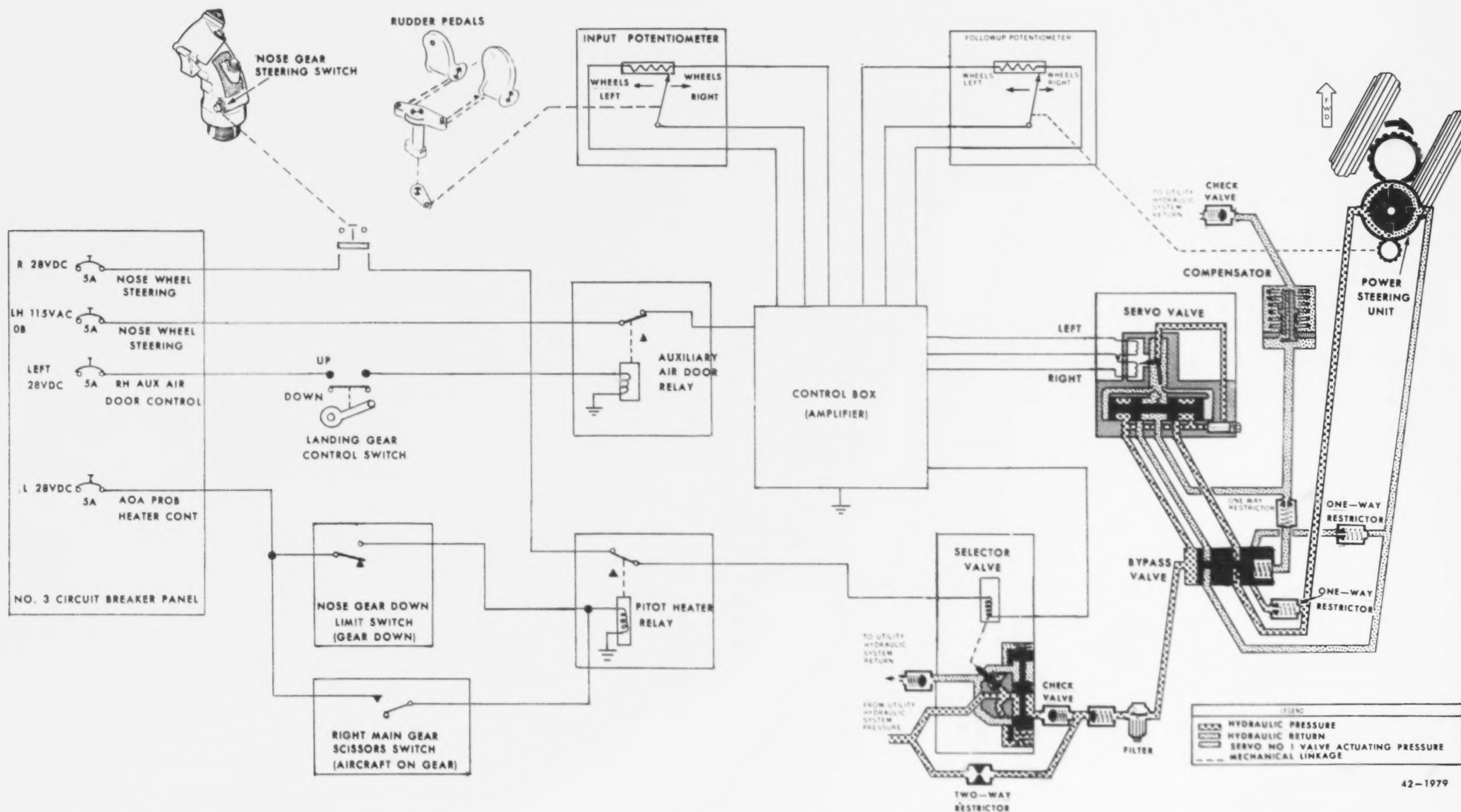


42-1976

Foldout 4. Landing gear (jackscrew operated DOWN).

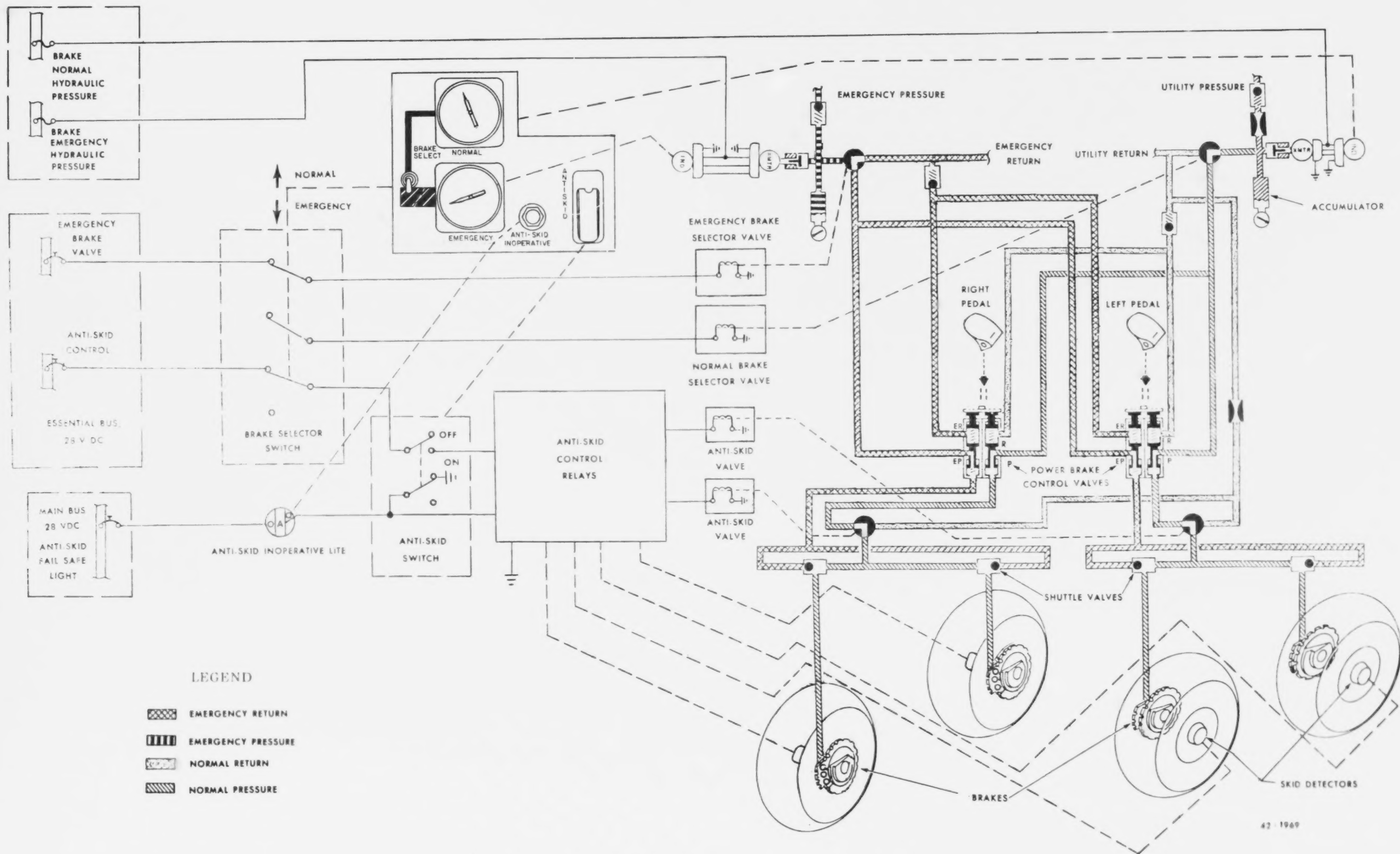


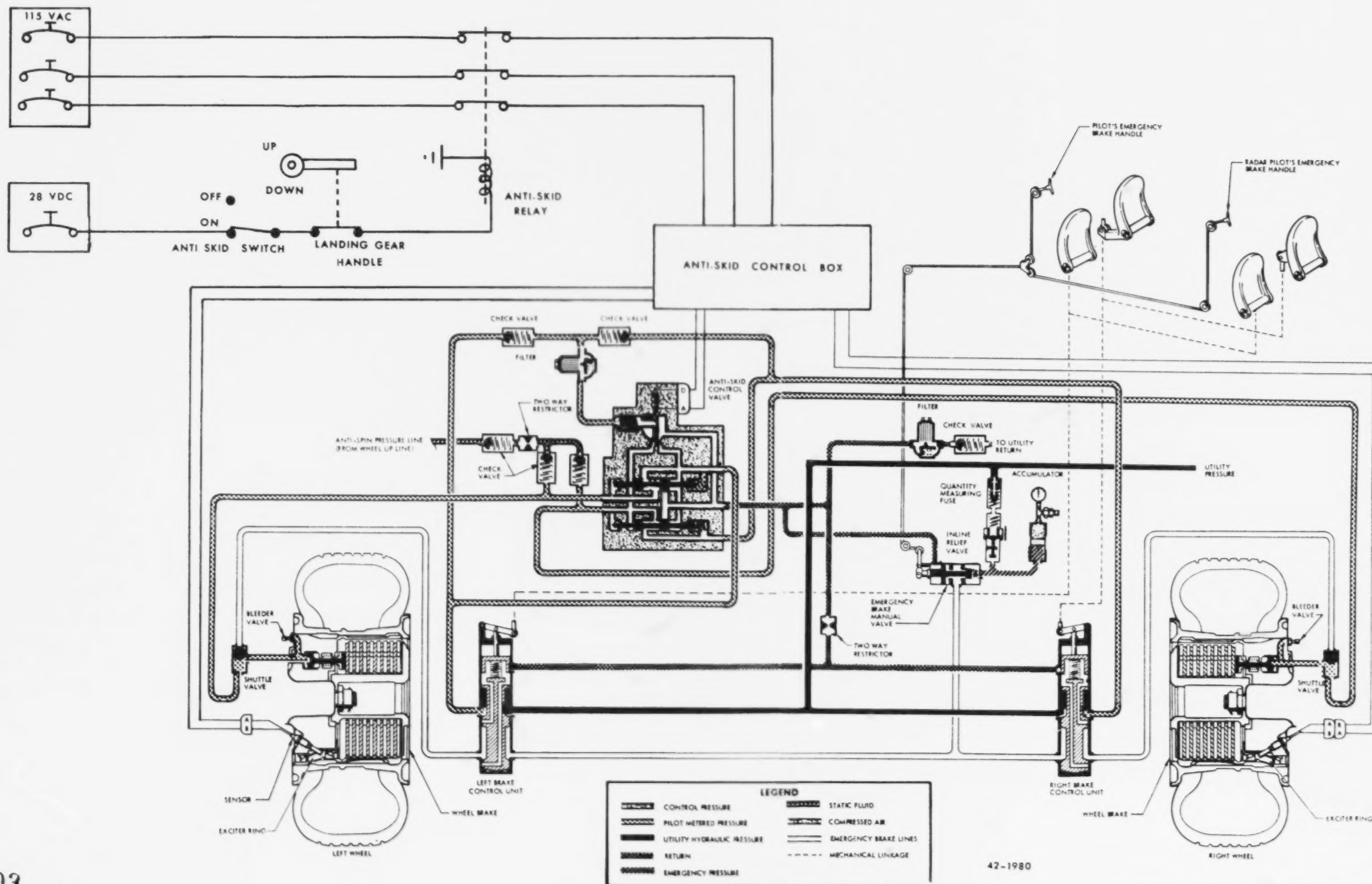
Foldout 5. Landing gear (emergency air).

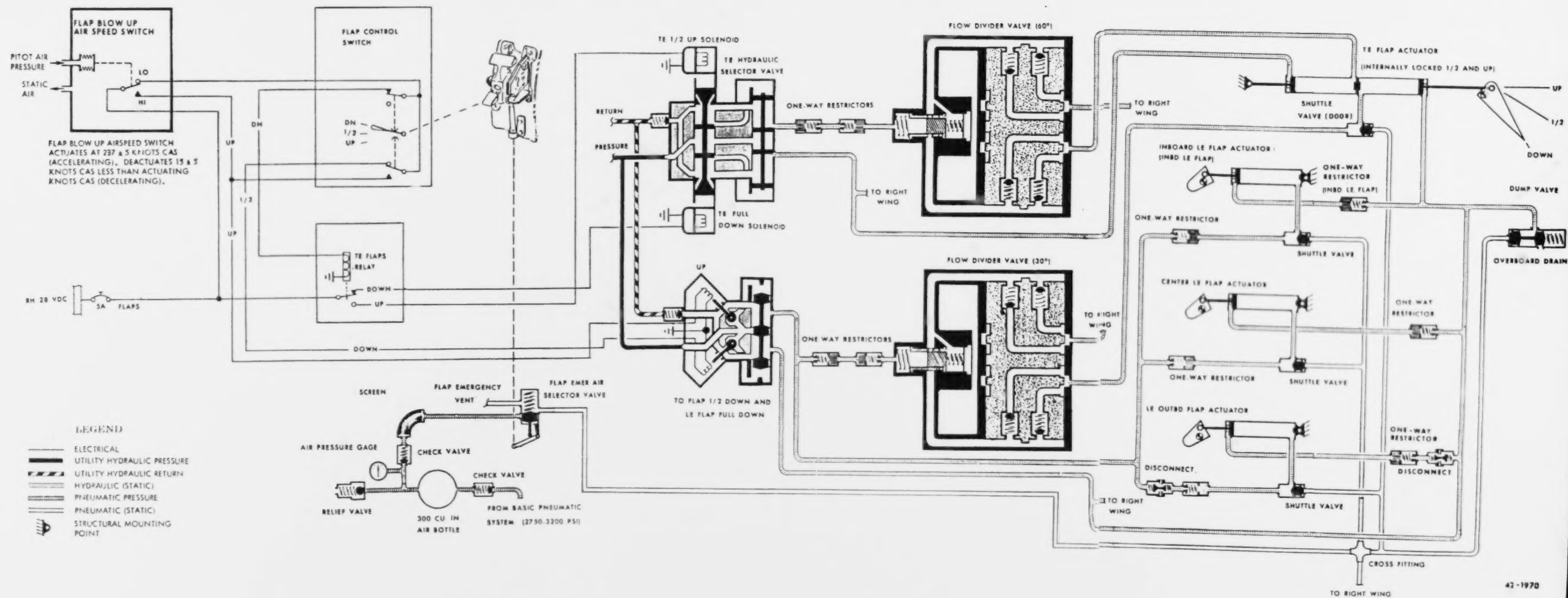


42-1979

Foldout 6. Nosewheel steering (electrically operated).

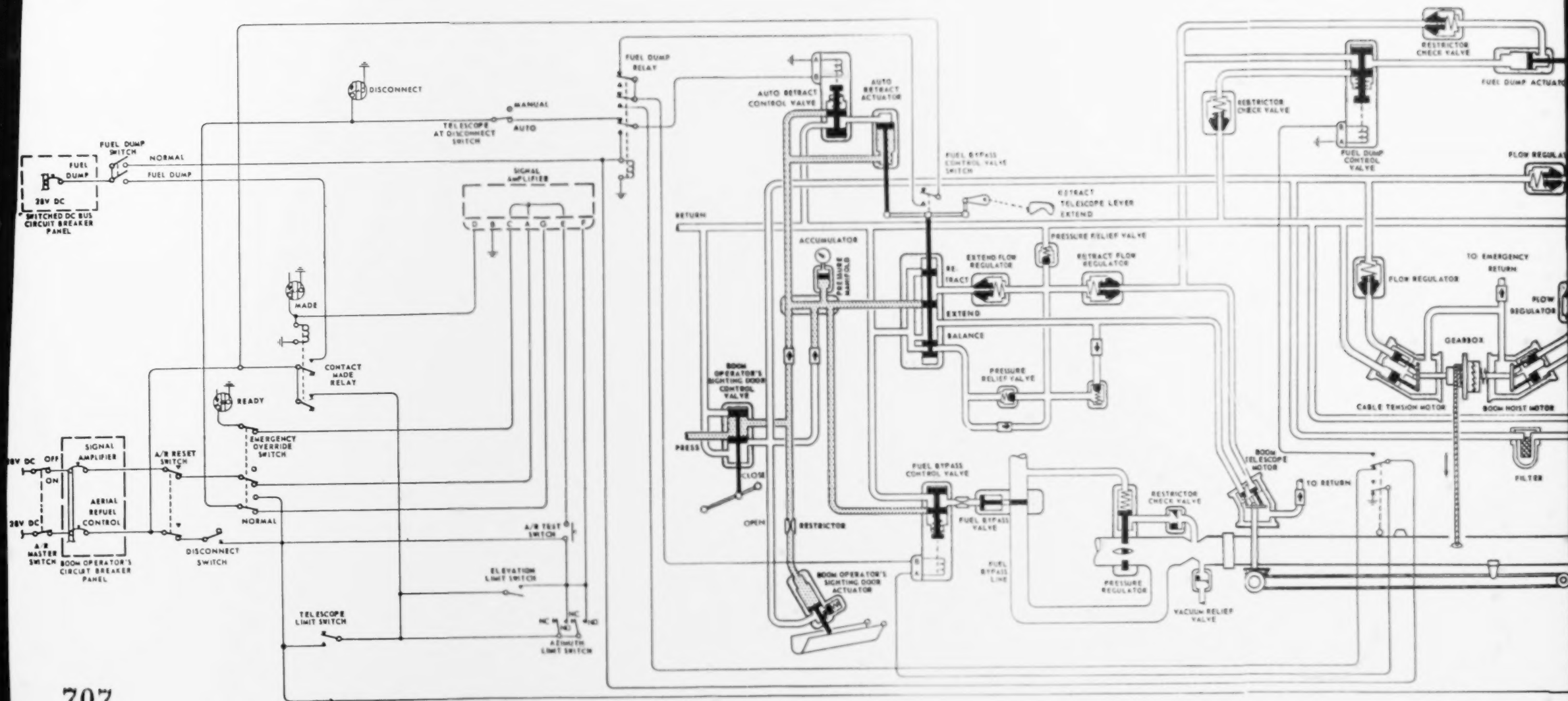


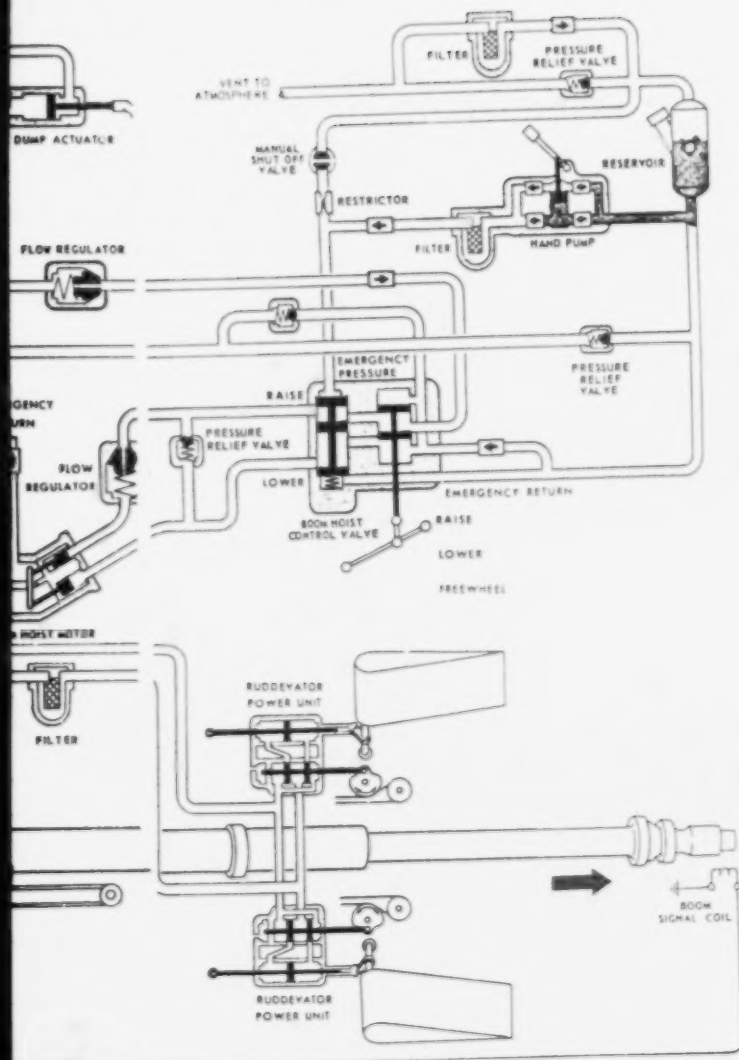




Foldout 9. Flap system.

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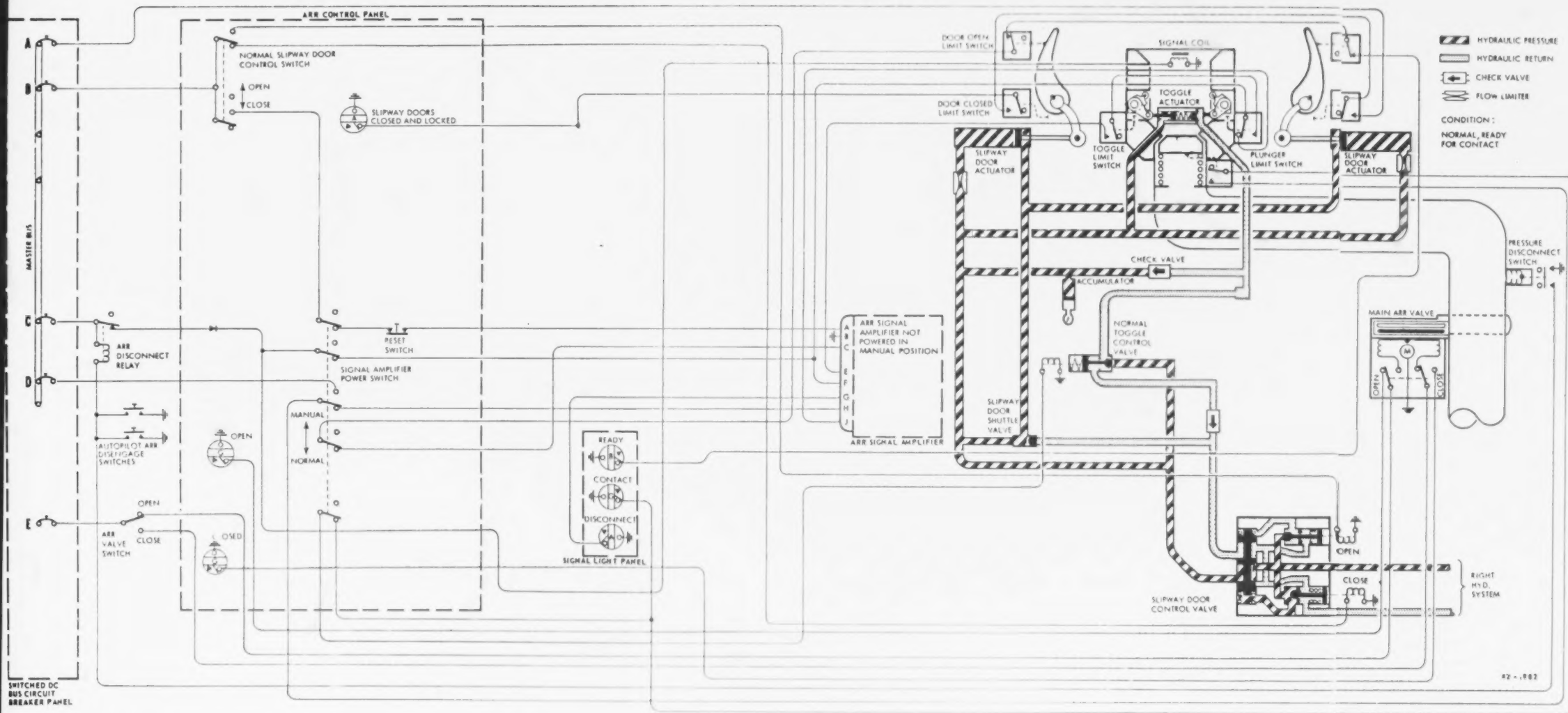




42-1971

Foldout 10. Air refueling systems.

708 A



Foldout 11. Receiver aircraft refueling system.

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STOP -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
42354 04 21
PNEUDRAULIC SYSTEMS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

42354-04-21

MULTIPLE CHOICE

1. (600) The run-around circuit of the hydraulic power system is to
 - a. cool the fluid.
 - b. bypass the filter element.
 - c. shut off fluid to the pump.
 - d. route shaft seal leakage overboard.
2. (600) The hydraulic suction boost pump is used to
 - a. pressurize the reservoir.
 - b. turn out the low pressure warning lights.
 - c. drain the fluid overboard from the reservoir.
 - d. insure a positive supply of fluid to the engine driven pumps.
3. (600) In an emergency, the engine driven hydraulic pumps shut-off valves may be operated by
 - a. stopping the engines.
 - b. pulling the fire handles.
 - c. pulling the circuit breaker.
 - d. stopping the suction boost pump.
4. (601) Hoses rather than metal tubings, are used on hydraulic power system pumps because they
 - a. have a longer life span.
 - b. can be stretched for easier installation.
 - c. have a higher burst pressure.
 - d. can absorb pump vibration or engine movement.
5. (601) Where does the fluid come from that is routed through the fuel radiator?
 - a. Return flow from the relief valve.
 - b. Reservoir suction line.
 - c. Pump case drain line.
 - d. Filter bypass.
6. (601) A piston type pump produces a natural "ripple" as each piston in the pump reaches its full stroke. Which of the following components is designed to eliminate this problem?
 - a. Pressure reducer.
 - b. Surge suppressor.
 - c. Flow control.
 - d. Relief valve.

42354-04-21

7. (602) Refer to figure 1-1 of the text. What prevents the air compressor from operating when the door is hanging down even though the pressure sensing switch is made?
- a. The thermostat.
 - b. Dump valve solenoid.
 - c. The access door limit switches.
 - d. Solenoid operated hydraulic selector valve.
8. (603) One of the most important things to do when putting the initial air charge in an accumulator is to be sure that the hydraulic system pressure reads
- a. zero.
 - b. 1,500 psi.
 - c. at the maximum.
 - d. the same as the preload.
9. (603) At least three basic items are listed on most reservoir data plates. Which of the following is not one of these?
- a. Type of reservoir.
 - b. Type of fluid use.
 - c. The position of the subsystem during servicing.
 - d. The system pressure that must exist before servicing.
10. (604) While running the engines on an aircraft, the pilot reports that the hydraulic pressure indicator is reading extremely low. How could you quickly verify that the indicator in the cockpit is reading correctly?
- a. Hook up a pressure gage to the engine pressure line.
 - b. Attach a hydraulic test stand to the aircraft.
 - c. Remove the indicator and check it in the shop.
 - d. Check the accumulator direct reading gage.
11. (605) Before an engine driven pump is installed on an aircraft,
- a. it should be primed.
 - b. it should be lubricated.
 - c. the pump should be flushed.
 - d. new fittings should be installed.
12. (605) What specific precaution should you take when installing a chemical drier cartridge in its housing?
- a. Install the protective covers.
 - b. Clean the exterior of the housing.
 - c. check the cartridge for corrosion.
 - d. Insure that the arrow and the word "flow" is pointing toward the outlet port.

13. (606) When contaminated fluid trapped in a hydraulic unit cannot be drained by disconnecting a line, the
- a. unit should be removed and drained.
 - b. unit should be condemned.
 - c. system should be flushed.
 - d. unit should be bypassed.
14. (606) Which of the following methods would be used to remove condensation from a system?
- a. Recycling.
 - b. Draining.
 - c. Flushing.
 - d. Purging.
15. (607) What is one advantage that the tricycle landing gear system has over the conventional landing gear of older aircraft?
- a. The gear system is easier to maintain.
 - b. Aircraft can land on shorter runways.
 - c. Less retracting area is required.
 - d. Forward takeoff visibility is improved.
16. (607) To halt a trend toward increasing strut, axle and wheel size to accommodate more weight, what major landing gear component was developed?
- a. Bicycle landing gear.
 - b. The quadricycle landing gear.
 - c. The truck (Bogie) type main gear.
 - d. The conventional type landing gear.
17. (608) Some aircraft have a locking device on the landing gear control lever. What must be done in order to raise the landing gear lever while the aircraft is on the ground?
- a. The lock release finger latch must be pulled down.
 - b. Electrical power must be applied to the aircraft.
 - c. The aircraft will have to be jacked.
 - d. hydraulic pressure must be applied.
18. (608) When the aircraft weight is on the gear, the lock pin on the landing gear lever is
- a. spring loaded to the unlocked position.
 - b. spring loaded to the locked position.
 - c. deenergized to the locked position.
 - d. energized to the locked position.

19. (609) On a landing gear warning system, a glowing red warning light in the landing gear control handle would indicate that the gear
- a. is UP and LOCKED.
 - b. is DOWN and LOCKED.
 - c. should be put into DOWN.
 - d. is between DOWN or UP and LOCKED.
20. (610) On the large aircraft landing gear system described in this volume, what is used to slow the main gear's retraction speed within the last few inches of gear travel?
- a. Piston.
 - b. Shuttle valve.
 - c. Selector valve.
 - d. Controllable restrictor valve.
21. (610) As used on the large aircraft landing gear system described in the volume, which of the following devices locks the main landing gear in the UP position?
- a. Stop lock pin.
 - b. Gear box brake.
 - c. Mechanical locking lever.
 - d. Hydraulic cylinder and piston.
22. (611) When the landing gear control lever is placed in the down position, electrical power
- a. must energize the emergency system.
 - b. must complete the circuit to the safety switch.
 - c. goes directly to the landing gear control valve.
 - d. must first make a complete circuit through the landing gear position switches.
23. (612) Which of the following would be used to prevent runway overrun?
- a. Drag chute, nosewheel steering, and brakes.
 - b. Drag chute, arresting gear, and brakes.
 - c. Flaps, speed brakes, and ailerons.
 - d. Tail wheel, flaps, and brakes.
24. (612) Using the tail hook system described in this text, the pilot uses which of the following means to determine when the hook is down?
- a. The sound of the hook striking the ground.
 - b. A buildup of pressure on the pressure gage.
 - c. A warning light in the control lever.
 - d. An ammeter indication.

25. (613) Why are the nose gear torque links disconnected on some aircraft before they are taxied?
- a. So the fluid can transfer from one cylinder to the other for shimmying action.
 - b. So that just the lower portion of the strut will rotate.
 - c. So that the strut can be rotated 360°.
 - d. To keep the strut from bottoming.
26. (614) What unit in the electrically controlled nosewheel steering system determines which coil of the servo valve will be energized?
- a. Amplifier.
 - b. Selector valve.
 - c. Input potentiometer.
 - d. Follow-up potentiometer.
27. (615) Which of the following antiskid circuits prevents the brakes from being applied during landing?
- a. Locked wheel skid control.
 - b. Touchdown protection.
 - c. Fail-safe protection.
 - d. Normal skid control.
28. (616) Antispin systems are installed on aircraft landing gear systems to
- a. prevent skidding.
 - b. apply the brakes during emergency.
 - c. stop wheel rotation during retraction.
 - d. release the brakes until the speed of the aircraft reaches 15 knots.
29. (616) What happens to the antiskid system when the brakes are being applied in emergency?
- a. The locked wheel circuit releases the brakes.
 - b. The antiskid system is inoperative in emergency.
 - c. The fail-safe protection circuit will apply the brakes.
 - d. The antiskid system will route both normal and emergency pressure to the brakes.
30. (617) Which of the following is not a primary concern when the aircraft brake system is being inspected?
- a. Wear.
 - b. Leakage.
 - c. Corrosion.
 - d. Proper servicing.

31. (618) While removing the main gear actuator on an aircraft, fluid sprayed out when a line was disconnected. In this case, the mechanic had forgotten to
- install the ground safety pins.
 - release the landing gear down lock.
 - depressurize the system.
 - cap or plug the lines.
32. (618) Basically, the only difference between removing and installing a landing gear is that
- electrical power must be applied during installation.
 - hydraulic power must be applied during installation.
 - removal procedures should be forgotten during installation.
 - new O-ring seals should be installed during installation.
33. (619) When performing an operational check of the landing gear system, the hydraulic test stand should be adjusted to
- simulate volume and pressure requirements of the engine driven pump.
 - insure that the lights are functioning properly.
 - insure that the emergency system operates.
 - simulate air speed requirements.
34. (620) To check the fluid level of a shock strut, you must first
- deflate the strut.
 - jack the aircraft.
 - remove the air valve assembly.
 - properly position your maintenance stand under the wing.
35. (620) To service a shock strut, which of the following should be used?
- | | |
|--------------|---------------|
| a. Oxygen. | c. Nitrogen. |
| b. Hydrogen. | d. Acetylene. |
36. (621) Caps and plugs are used when a hydraulic component is removed from the aircraft to
- prevent dirt from entering and contaminating the system.
 - identify the tubing and hose for proper reconnection.
 - make it easier to remove the component.
 - reduce overall handling precautions of the component.

37. (622) Why are some aircraft placed on grease plates when performing an operation check of the nosewheel steering system?
- a. It reduces the time of the operational check.
 - b. The hydraulic pressure will build up faster.
 - c. It makes it easier for adjusting the travel.
 - d. It eliminates binds on the gear when positioning it.
38. (623) The text describes which two methods used for bleeding the brakes?
- a. Return and pressure.
 - b. Pressure and gravity.
 - c. Gravity and bleeding.
 - d. Pressure and bleeding.
39. (623) When an aircraft is equipped with power brake control valves, which method is usually used for bleeding the brakes?
- a. Return flow.
 - b. Bleeding.
 - c. Pressure.
 - d. Gravity.
40. (624) If excessive hydraulic fluid leakage is found in and around the left brake assembly, your first step aimed at correcting the problem is to
- a. perform an operational check.
 - b. tighten the brake pressure line.
 - c. replace the seals on the brake.
 - d. bleed the brakes.
41. (625) If, in bench checking a part, you find that the pressure port fitting has been cross-threaded, you should
- a. order a new body but continue with the bench check to find anything else that might be wrong.
 - b. order a new body and wait until it comes in before you continue the bench check.
 - c. make a note of it and continue with the bench check to determine if there is anything else wrong.
 - d. repair it and continue with the bench check to look for further problems.
42. (625) Which of the following parts are always replaced during overhaul of a hydraulic component?
- a. The threaded fittings.
 - b. The needle valves and seats.
 - c. All springs and poppets.
 - d. All O-ring seals and gaskets.

43. (626) Which of the following reference lines is often used in discussing an airfoil?
- a. Horizontal line.
 - b. Vertical line.
 - c. Lateral line.
 - d. Chord line.
44. (626) If the lift of an aircraft is equivalent to its weight, theoretically, the aircraft should
- a. climb slowly.
 - b. descend slowly.
 - c. fly erratically.
 - d. maintain a constant altitude.
45. (627) Which flight control surface guides the movement of the aircraft about the vertical axis?
- a. Rudder.
 - b. Aileron.
 - c. Elevator.
 - d. Wing flap.
46. (627) Which flight control surface was designed to prevent shock waves from affecting the aircraft's flight around its horizontal axis at transonic speeds?
- a. Movable horizontal stabilizer.
 - b. Spoilers.
 - c. Elevator.
 - d. Flaps.
47. (628) Which of the following systems was developed to give the pilot a simulated aerodynamic load?
- a. Electrical trim.
 - b. Artificial feel.
 - c. Autopilot.
 - d. Stab. aug.
48. (628) Which of the following flight control systems is used to make the aircraft a stable platform from which weapons can be launched?
- a. Feel trim.
 - b. Autopilot.
 - c. Stab. aug.
 - d. Electrical trim.
49. (629) Cable tension is adjusted by means of
- a. rod ends.
 - b. turnbuckles.
 - c. quick disconnects.
 - d. a cable tensiometer.
50. (629) What component in a flight control system is used to change the direction of a cable?
- a. Pulley.
 - b. Fair lead.
 - c. Turnbuckle.
 - d. Cable quick disconnect.

51. (630) On the large aircraft system described in the text, why is the rudder system pressure lowered when the aircraft is flying at high speeds?
- a. To increase rudder trim.
 - b. To eliminate vibrations.
 - c. To increase maneuverability.
 - d. To prevent rudder supporting structure damage.
52. (630) On a large aircraft that uses shutoff valves in the rudder system, when the auto-pilot is used, the rudder control valve is positioned by
- a. the servomotor.
 - b. the rudder pedals.
 - c. a shut-off valve.
 - d. a diverter valve.
53. (631) Lateral control, as used on the fighter type aircraft described in the text, is accomplished by simultaneous operation of the
- a. flaps and rudder.
 - b. rudder and elevator.
 - c. ailerons and spoilers.
 - d. elevator and speed brakes.
54. (632) What could happen if the flap asymmetry system is not working properly?
- a. The aircraft will assume a nose-up attitude.
 - b. A violent roll of the aircraft could occur.
 - c. The flaps will lower, but could not raise.
 - d. All flight controls will be inoperative.
55. (632) On the large aircraft flap system described in the text, what happens when the left and right flaps become unsynchronized?
- a. The aircraft will pitch up.
 - b. The gear box will be damaged.
 - c. The asymmetry brake will be applied.
 - d. Emergency pressure will lower the flaps.
56. (633) What position will the flaps assume when the handle in the cockpit is positioned to 1/2 down?
- a. Only the leading edge flaps will go 1/2 down.
 - b. Only the trailing edge flaps will go to 1/2 down.
 - c. Both the leading edge and trailing edge will go to 1/2 down.
 - d. The leading edge flaps will go full down and the trailing edge will go to 1/2 down.

57. (633) When the air speed exceeds a specified amount on the flap system, the flaps will
- a. be controlled by the asymmetry system.
 - b. automatically raise.
 - c. automatically lower.
 - d. lower in emergency.
58. (634) Which of the following should be used to check the travel of the ailerons on an aircraft?
- a. Template.
 - b. Manometer.
 - c. Micrometer.
 - d. Fish scale.
59. (635) During removal of a component in the flight control system, the hydraulic lines and hoses should be tagged to prevent
- a. loss.
 - b. cavitation.
 - c. contamination.
 - d. cross-connection.
60. (635) One of the first things you should do prior to installing a component in the flight control system is to
- a. read the installation instructions completely.
 - b. service the component with fluid.
 - c. deplete system pressure.
 - d. adjust the component.
61. (636) When the boom is being flown, the boom hoist lever must be in which position?
- a. Hold.
 - b. Raise.
 - c. Lower.
 - d. Free wheel.
62. (636) Which of the following is used to fly the inflight refueling boom?
- a. Ruddevator control stick.
 - b. Pilot's control wheel.
 - c. Boom telescope lever.
 - d. Boom hoist lever.
63. (637) The sprocket driven chain and cable assembly used to telescope the A/R boom is attached to the
- a. outer fuel tube.
 - b. inner fuel tube.
 - c. inner structural tube.
 - d. outer structural tube.

64. (637) Disconnect high-pressure fuel surges are absorbed in the A/R boom by the
- nozzle damper.
 - spring ring assembly.
 - shock absorber assembly.
 - tandem-mounted surge boots.
65. (638) While an ARR aircraft is in contact with the air refueling (tanker) aircraft, the receiver aircraft pilot should pay particular attention to the director lights to
- insure that the receiver aircraft stays within the envelope limits of the boom.
 - determine how far the receiver aircraft has moved in azimuth.
 - determine how far the boom has extended.
 - insure that the lights are working.
66. (638) During night refueling operations, the boom marker lights
- are used to position the receiver aircraft.
 - cause the markings on the boom to glow.
 - light up when the boom is stowed.
 - light the boom nozzle.
67. (639) What unit is installed in the air refueling fuel manifold to sense fuel flow?
- Line valve.
 - Flow regulator.
 - Manifold venturi.
 - Fuel manifold vacuum relief valve.
68. (640) When the boom operators' sighting door control lever is moved to the CLOSE position, hydraulic pressure is shut off to the
- ruddevators, hoist motor, and sighting door.
 - ruddevators, hoist motor, and tension motor.
 - hoist motor, tension motor, and sighting door.
 - hoist motor, boom telescope valve, and fuel dump actuator.
69. (640) What valve, when open, will allow the fuel trapped in the boom during retraction to return to the aircraft fuel tank?
- Fuel pressure regulator valve.
 - Nozzle check valve.
 - Fuel bypass valve.
 - Fuel dump valve.

70. (641) READY, MADE, and DISCONNECT signals are transmitted between the tanker and receiver aircraft to automatically control the
- a. hydraulic and fuel systems.
 - b. position indicators.
 - c. fuel system only.
 - d. signal coil.
71. (641) A DISCONNECT signal may come from
- a. the boom operators DISCONNECT switch.
 - b. the receiver signal system.
 - c. the azimuth, telescoping or elevation limit switches.
 - d. any of the above sources.
72. (642) The ARR hydraulic system opens the slipway doors by applying pressure to
- a. the toggle lock actuator.
 - b. the toggle control valve.
 - c. both sides of the slipway door actuators.
 - d. either side of the slipway door control valve.
73. (643) Caution must be observed when operationally checking the air refueling indicating system because dangerous voltage can be induced in the boom if the
- a. aircraft generators are turning.
 - b. radio equipment is operating.
 - c. external power is applied.
 - d. battery is turned on.
74. (644) While inspecting the A/R system, you should check the signal coil on the nozzle for
- a. leakage.
 - b. binding.
 - c. corrosion.
 - d. broken lines.
75. (645) When trouble shooting a malfunction on the aircraft, which of the following could you use to simplify the task?
- a. Trouble shooting chart.
 - b. -6 technical order.
 - c. Pilot's checklist.
 - d. Numerical index.

ATC/ECI SURVEY

The remaining questions (125-135) are not part of the Volume Review Exercise (VRE). These questions are a voluntary ATC/ECI survey. Using a number 2 pencil, indicate what you consider to be the appropriate response to each survey question on your answer sheet (ECI Form 35), beginning with answer number 125. Do not respond to questions that do not apply to you. Your cooperation in completing this survey is greatly appreciated by ATC and ECI. (AUSCN 100)

PRIVACY ACT STATEMENT

- A. Authority: 5 U.S.C. 301, Departmental Regulations
- B. Principal Purpose: To gather preliminary data evaluating the ATC/ECI Career Development Course (CDC) Program.
- C. Routine Uses: Determine the requirement for comprehensive evaluations in support of CDC program improvement.
- D. Whether Disclosure is Mandatory or Voluntary: Participation in this survey is entirely voluntary.
- E. Effect on the Individual of not Providing Information: No adverse action will be taken against any individual who elects not to participate in any or all parts of this survey.

QUESTIONS:

125. If you have contacted ECI for any reason during your enrollment, how would you describe the service provided to you?

- a. Excellent.
- b. Satisfactory.
- c. Unsatisfactory.
- d. Did not contact ECI.

126. My ECI course materials were received within a reasonable period of time.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

127. The condition of the course materials I received from ECI was:

- a. A complete set of well-packaged materials.
- b. An incomplete set of well-packaged materials.
- c. A complete set of poorly packaged materials.
- d. An incomplete set of poorly packaged materials.

128. The reading level of the material in the course was too difficult for me.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

129. The technical material in the course was too difficult for me at my present level of training.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

130. The illustrations in the course helped clarify the information for me.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

131. Approximately how much information in the course provides general information about your AFSC?

- a. Between 80 and 99%.
- b. Between 60 and 79%.
- c. Between 40 and 59%.
- d. Between 20 and 39%.

132. Approximately how much information in this course was current?

- a. Between 80 and 99%.
- b. Between 60 and 79%.
- c. Between 40 and 59%.
- d. Between 20 and 39%.

133. The format of the text (objective followed by narrative and exercises) helped me study.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

134. The volume review exercise(s) helped me review information in the course.

- a. Strongly agree.
- b. Agree.
- c. Disagree.
- d. Strongly disagree.

135. Check the rating which most nearly describes the usefulness of the information in this CDC in your upgrade training program.

- a. Excellent.
- b. Satisfactory.
- c. Marginal.
- d. Unsatisfactory.

NOTE: If you know this CDC contains outdated information or does not provide the knowledge that the current specialty training standard requires you to have for upgrade training, contact your OJT advisor and fill out an AF Form 1284, Training Quality Report.

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 44 USC 3101. PRINCIPAL PURPOSE(S): To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with every ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: MAIL TO: ECI, GUNTER AFS, ALA 36118

1. THIS REQUEST CONCERNS COURSE 	2. TODAY'S DATE 	3. ENROLLMENT DATE 	4. PREVIOUS SERIAL NUMBER
5. SOCIAL SECURITY NUMBER - -	6. GRADE/RANK 	7. INITIALS 	LAST NAME
8. OTHER ECI COURSES NOW ENROLLED IN 	9. ADDRESS: (OJT ENROLLEES - ADDRESS OF UNIT TRAINING OFFICE/ALL OTHERS - CURRENT MAILING ADDRESS) 		11. AUTOVON NUMBER
	ZIP CODE 		12. TEST CONTROL OFFICE ZIP CODE/SHRED
	10. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE: 		

SECTION II: Old or INCORRECT ENROLLMENT DATA

1. NAME:	2. GRADE/RANK:	3. SSAN:
4. ADDRESS:	5. TEST OFFICE ZIP/SHRED:	

SECTION III: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. The latest course workbooks have a Form 17 printed on the last page.

(Place an "X" through number in box to left of service requested)

1	EXTEND COURSE COMPLETION DATE. (Justify in Remarks)
2	SEND VRE ANSWER SHEETS FOR VOL(s): 1 2 3 4 5 6 7 8 9 - ORIGINALS WERE: NOT RECEIVED, LOST, MISUSED
3	SEND COURSE MATERIALS (Specify in remarks) - ORIGINALS WERE: NOT RECEIVED, LOST, DAMAGED.
4	COURSE EXAM NOT YET RECEIVED. FINAL VRE SUBMITTED FOR GRADING ON (Date):
5	RESULTS FOR VRE VOL(s): 1 2 3 4 5 6 7 8 9 NOT YET RECEIVED. ANSWER SHEET(s) SUBMITTED ON (Date):
6	RESULTS FOR CE NOT YET RECEIVED. ANSWER SHEET SUBMITTED TO ECI ON (Date):
7	PREVIOUS INQUIRY (ECI FORM 17, LTR, MSG) SENT TO ECI ON:
8	GIVE INSTRUCTIONAL ASSISTANCE AS REQUESTED ON REVERSE:
9	OTHER (Explain fully in remarks)

REMARKS: (Continue on Reverse)

OJT STUDENTS must have their OJT Administrator certify this request.
ALL OTHER STUDENTS may certify their own requests.

I certify that the information on this form is accurate and that this request cannot be answered at this station. (Signature)

ECI FORM 17 JUN 77 PREVIOUS EDITIONS MAY BE USED

SECTION IV: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of textual material should be forwarded directly to preparing agency. Name of agency can be found at the bottom of the inside cover of each text. All other inquiries concerning the course should be forwarded to ECI.

VRE ITEM QUESTIONED:

MY QUESTION IS:

Course No. _____

Volume No. _____

VRE Form No. _____

VRE Item No. _____

Answer You Chose
(Letter) _____

Has VRE Answer Sheet
been submitted for grading?

☐ YES ☐ NO

REFERENCE

(Textual support for the
answer I chose can be
found as shown below)

In Volume No: _____

On Page No: _____

In _____ (Left) _____ (Right)
Column

Lines _____ Through _____

Remarks: